PROCEEDINGS

OF THE

AMERICAN PHILOSOPHICAL SOCIETY.

HELD AT PHILADELPHIA, FOR PROMOTING USEFUL KNOWLEDGE.

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Stated Meeting, June 16, 1876.

Present, 7 members.

Vice-President, MR. FRALEY, in the Chair.

Letters accepting membership were received from Dr. A. E. Nordenskiold, dated Philadelphia, June 13, 1876, Dr. Juhlin Dannfelt, dated Philadelphia, May 31, 1876, Mr. I. Lothian Bell, dated Philadelphia, June 7, 1876, and Mr. P. Cunliffe Owen, dated 2 Residences, South Kensington Museum, London, May 20, 1876.

A photograph of Dr. I. Lea, of Philadelphia, was received for insertion in the Album.

Receipts for No. 92 Proceedings were received from M. M. Rokitansky & Hyrtl, of Vienna.

A letter of envoy was received from the Royal Bavarian Library, dated March 18, 1876.

Notice of change of residence from St. Petersburg to Jena of M. Böhtlinek was received from Watkins & Co. per Smithsonian Institution.

Donations for the Library were announced from the Academies at Berlin, Munich, Boston, Philadelphia, and San Francisco; the Societies at Leipzig, Ulm, Salem and Boston; the Observatory at Munich; the Library at Munich; the Editors of the Revue Politique, and Nature; the London Geographical, Astronomical, and Zoological Societies; Mr. Edmund Quincy, Prof. O. C. Marsh, Dr. Isaac Lea; Silliman's Journal, American Chemist, Journal of Pharmacy, Penn Monthly, and the Massachusetts State Board of Health.

The Committee on Dr. Valentino's Memoir reported progress, and was continued.

The death of Dr. Geo. Allen was announced by the Secretary, and on motion Prof. Thompson, of the University of Pennsylvania, was appointed to prepare an obituary notice of the deceased.

Mr. Price communicated the following circular, read and

unanimously adopted at a meeting of the Commissioners of Fairmount Park, held June 5, 1876:

TREES FOR THE FAIRMOUNT PARK.

This Park is in the earliest stage of its formation. A principal feature of its beauty must consist of trees, planted in manner to form pleasing landscapes, and in trees planted singly, in groups, and groves. The Commissioners desire also to add a botanical interest to the Park, by having in it every tree that will stand our climate. To promote this object and duly to honor the name of Michaux, father and son, the American Philosophical Society have devoted half the income of the legacy left by the son to the Society, of about three hundred dollars ($300) per annum. This has been applied to the planting of the Michaux Grove of oaks, and to importing and planting in our nurseries many varieties of oaks, &c. The announcement is now made, during the holding of the Centennial International Exhibition as an auspicious occasion to invite contributions of trees, acorns and seeds, from all parts of the world, and from all persons who love the beautiful in landscape and to promote botanical science.

Communications may be made to Eli K. Price, No. 709 Walnut Street, Philadelphia, Chairman of Committee on Trees and Nurseries in the Park Commission, and Chairman of the Committee on Michaux Fund in the American Philosophical Society.

Mr. Price exhibited specimen twigs, bearing leaves, broken from every variety of oak imported and growing in the Michaux Grove. Respecting this grove he desired to have this minute placed on the Journal of the Society.

The Chairman of the Committee on the Michaux Grove reports, that he has visited to day the Fairmount Park Nursery, and found the grounds well taken care of, and the large stock of trees in a flourishing condition. Of the acorns planted before last winter nearly all have grown except those of the "Bartram Oak;" and of the fifty or sixty of these planted, not one has grown. So far the proof is in favor of that oak being a hybrid.

Mr. Davenport being invited to speak of the Eucalyptus trees of Australia, and the probability of growing certain species of Eucalyptus in our latitude, remarked that his botanical information was drawn chiefly from the pretty thorough reconnoisance of that continent by Dr. Schomberg, Director of the Botanical Gardens at Adelaide, and Baron

von Müller, Director of the Gardens at Melbourne, who recognized about one hundred and fifty species or varieties of Eucalyptus, many of large size, some growing grandly on arid plains, others on Australian "Alps" and "Pyranees" at various elevations; the highest mountain summits being not above 7000 feet over sea level. Some of these mountain kinds will probably grow in Philadelphia, and he will be happy to assist their introduction. He had seen large plantations of Eucalyptus between St. Jose and San Francisco, and others growing in the interior. He had come to the conclusion in his own mind many years ago that the fragrance diffused through the Australian atmosphere by the essential oils of these trees must account in part for the remarkable immunity which settlers and travelers, however exposed at night in the bush, had always enjoyed against malarious fevers, although the climate was as hot as in malarious districts of Italy. No malaria was known, although low typhoid fevers were not unknown.

Mr. Davenport remarked the great difference between the vegetation of Adelaide and Philadelphia, and had been much impressed by the exuberant foliage of the Park around the Centennial grounds.

Prof. Houston reported the result of his proposed experiment with the 19″ Fresnel lens through which, about two weeks ago, he had concentrated the beams of a full moon in a spot of about a quarter of an inch diameter, on the flags of a Crooke's radiometer, without obtaining the least movement; whereas the same instrument, at the same time, was moved by the heat of boiling water in a glass tube, but was not sensitive to radiant heat below about 212°. In a room, however, the heat of the hand would move it, a lighted match would make it move swiftly, even the dull red glow of the extinguished end of a match gave a sensible motion.

Pending nominations 793 and 803 were read.

And the meeting was adjourned.

Stated Meeting, July 21, 1876.

Present, 6 members.

Dr. LeConte in the Chair.

The reading of the minutes was dispensed with.

Letters of acknowledgment were received from Mr. C. E. Dutton, dated Omaha (97), and Mr. A. H. Worthen, Warsaw, Ill. (97).

A letter of envoy was received from the Smithsonian Institution, dated Washington, July 20.

A letter was received from Prof. Charles E. Anthon, dated College of the City of New York, June 29, 1876, with the coin and description referred to in his letter of February 11th, read at the meeting of February 18, 1876.

A letter was received from Mr. Charles A. Kesselmeyer, dated 1 Peter Street, Manchester, England, 21st June, 1876, presenting to the Society a copy of his "Calendarium Perpetuum Mobile," and enclosing a photograph with an explanation of the same.

Donations for the Library were received from the Berlin Physical Society; German Geological Society; Royal Prussian Academy; Dr. L. Wedekunde; Bamburg, Freiburg, and Chemnitz Natural History Societies; F. Kramer; Ulm Antiquarian Society; Royal Academy of Belgium; Royal Academy, Amsterdam; Netherland Botanical Society at Nimegen; Paris Geographical Society; Bureau des Longitude; Annales des Mines; Academy of Medicine; Editors of Nouvelles Météorologiques and Revue Politique, Paris; Col. E. Belleville; Turin University Observatory; G. Mazzola; Prof. A. Dorna; Society of Arts, Victoria Institute, Royal Asiatic, and Astronomical Societies, and Nature, London; Royal Society, Tasmania; Academy of Arts and Sciences, Connecticut; Silliman & Dana; Yale College; Mr. Osman Fisher; Essex Institute, Salem; Peabody Institute; Editors of American Chemist; Dr. C. H. Berendt; Pharma-

ceutical Association; Editors of the Penn Monthly; Franklin Institute; Editors of the Medical News and Journal; Mr. Robert Briggs, C.E.; Baltimore Peabody Institute; United States National Museum; Geological Survey of the Territories; G. B. Goode; Dr. Newberry; East Tennessee University; Academy of Science, St. Louis; G. A. Engelmann; and Hudson Hall, Savannah.

A donation for the Cabinet was received from Prof. Charles E. Anthon, of a coin of 1670, the date of the settlement of Quebec, struck by order of Louis XIV., the first currency of French North America.

The death of Prof. J. J. Kaup, of Darmstadt, was announced by letter of Prof. Joseph Henry, dated July 20, 1876.

A communication received from Prof. Charles E. Anthon was entitled, "On a Silver Louis of Fifteen Sous, struck under Louis XIV. for circulation."

Prof. Chase communicated a note on suggestions of Cosmical and Kinetic Harmony by Profs. Alexander, Pierce, Lovering, and others, and on some of the mathematical principles involved.

Pending nominations 793 and 803 were read and balloted for.

The letters of Prof. Henry and Charles A. Kesselmeyer were referred to the Secretaries with power to act.

On scrutiny of the ballot boxes, the following persons were declared by the presiding officer duly elected members of the Society, viz:

Prof. Richard Ackerman of Sweden.

Prof. John Johnson of Middletown, Conn.

And the meeting was adjourned.

Stated Meeting, August 18, 1876.

Present, 6 members.

Vice-President, MR. FRALEY, in the Chair.

The minutes of the last meeting were read.

Letters of envoy were received from the Smithsonian Institution, U. S. Coast Survey Office, London Meteorological Office, Boston Society of Natural History, and Gen. Henry L. Abbot.

Letters of acknowledgment were received from the Boston Society of Natural History, July 28th, (XV, ii.; 94, 97); Royal Astronomical Society, London, July 11th (XV, ii.; 62, 88); East Tennessee University, Knoxville, July 22d (97); and various libraries and members receiving Proceedings No. 97.

A letter was received from Prof. G. A. Matile requesting the loan of archæological specimens from the Cabinet to make casts from them for the Princeton Museum.

Photographs of Prof. Thomas C. Archer and Dr. H. R. Göppert were received for the Album.

Donations for the Library were received from the Academies at Berlin and Bruselles; the Congress of Naturalists at Berlin; the Societies at Marburg, Görlitz, Bremen, and Bordeaux; Zoological Garden at Frankfort; Geographical Society, Editors of the Revue Politique, and M. P. Frémeaux, at Paris; Royal Astronomical Society, Mr. T. H. Tizard, Mr. J. M. Stuart, and Editors of Nature, London; Geological Survey of Canada; Silliman & Dana, New Haven; Editors of the Penn Monthly, Medical News, and American Journal of Pharmacy, Philadelphia; Gen. H. L. Abbot; U. S. Coast Survey; Dr. Newberry, and the Rio Janeiro Museum.

Mr. Chase remarked upon the closeness of agreement between the estimates of solar radiating force derived from Crook's Radiometer and from the Nebular Hypothesis.

Dr. Cresson described successful experiments with Wootten's method of utilizing coal dust in locomotives and ocean steamers, and in puddling iron; exhibiting samples of the iron refined in the process.

New nomination 804 was read.

Mr. Fraley reported as received and paid to the Treasurer the interest on the Michaux Legacy, due July 1, 1876.

On motion of Mr. Chase, seconded by Dr. LeConte, the Curators were authorized to furnish Profs. Guyot and Matile such antiquities as they may wish to copy, taking the usual guarantees for their safe return.

Applications of Messrs. Trübner & Co., and others, for copies of Transactions and Proceedings, were referred to the Librarian with power to act.

And the meeting was adjourned.

Stated Meeting, September 15, 1876.

Present, 15 members.

Vice-President, Mr. Fraley, in the Chair.

Letters of acknowledgment were received from the Leipzig Astronomical Society, dated May, (xiv., 93, 94, 95); the Teyler Foundation, Harlem (94); the Royal Society of Science, Göttingen, April (XV, 94); the Central Institute of Meteorology at Vienna, June (93, 94); the Royal Academy, Amsterdam, March 12 (XV, i. ii., 94 and XV, 93); the U. S. Naval Observatory, Washington, June 30, (97); and the Zoologico-Botanical Society, Vienna, May (92).

Letters of envoy were received from the Royal Observatory, Turin, dated July 18; Royal Academy, Amsterdam, December 15, 1874; Mr. Geo. Engelmann, St. Louis, July 6; the Department of the Interior, and the Department of State, Washington, June 29th and August 17, 1876.

Donations for the Library were received from the Academies at Copenhagen, Brussels, Rome, and Philadelphia; the Geological, Zoological, and Anthropological Societies at Vienna; the Art Union at Ulm; the Geographical Society, Editors of Nouvelles Météorologiques and Revue Politique, at Paris; the Antiquarian Society, Dr. Joseph Prestwick, and the Editors of Nature, in London; the Melbourne Mining Survey; Maine Historical Society; Essex Institute; Dr. H. Carrington; Boston Society of Natural History; Hon. R. C. Winthrop; Dr. S. A. Green; Silliman & Dana, New Haven; Editors of the American Chemist; Prof. G. A. Matile, Franklin Institute, College of Surgeons, and Editors of the Penn Monthly, Medical News, and Journal of Pharmacy, in Philadelphia; U. S. Departments of War and State, Surgeon General, and Signal Service Bureau, Washington; Editor of the Scientific Monthly at Toledo; U. Stempel at Chicago; and Dr. Jarvis of Dorchester, Massachusetts.

A photograph of Dr. T. S. Hunt was presented for insertion in the Album.

A letter from Prof. J. Henry, requesting attention to a letter from the Holland Society of Science, was referred to the Librarian with power to supply deficiencies in the series of A. P. S. Publications in the Library of that Society.

A letter from the Freiburg Natural History Society was referred to the Librarian with power to supply Proc. 89.

A letter respecting deficiencies was received from the Society at Würtemburg and referred to the Librarian.

A letter from D. S. Sheldon, Librarian of Griswold College, Davenport, Iowa, asking for Dr. Hor. Wood's memoir on Myriapoda was referred to Dr. Wood.

A circular was received from the Société des Voyages at Paris.

Mr. Lesley exhibited a neatly executed colored geological lithograph map of Mr. B. S. Lyman's Official Survey of the Island of Yesso, as the first work of the kind done in Japan.

Dr. Hunt, on invitation, described the history of geological opinion respecting the gneisses, green rocks and other metamorphic strata of the Alps, with the recent accordance of the views of Gastaldi and Favre, as opposed to those of Lory and others, with previously published views of his own, after he had recognized the Laurentian, Huronian and Montalban systems in the massif of Mont Blanc.

Pending nominations Nos. 804, 805, 806, and 807 were read.

On motion the use of the Hall was granted to the Commissioners of the Geological Survey for their meeting on the 19th inst.

On motion of Mr. Pearse it was resolved, That the Board of Commissioners be requested to recommend to the Governor of Pennsylvania the propriety of taking such measures as may be necessary for preserving the collections of the Geological Survey in the same place in which the collections presented by the Commissioners of foreign governments may be arranged.

And the meeting was adjourned.

Stated Meeting, October 7th, 1876.

Present, 10 members.

Secretary, Dr. Le Conte, in the Chair.

Dr. Moor, a newly elected member, was introduced to the presiding officer and took his seat.

A letter of acknowledgment was received from the Observatory at Prague, dated Sept. 4 (XV, ii, 93, 94), from the R. Geological Society of Ireland, Sept. 16th (XIV Proc.), and from various correspondents by postal cards (97).

Letters of envoy were received from the Society at Marburg, April 1876;—the French Ministry of Public Works, Sept. 1876, desiring a return donation of some books on civil engineering or technology for the library of the Ecole des Ponts

et Chaussées in Paris; from the Linnean Society, dated London, Aug. 18th; from the Meteorological Office, dated London, Aug. 1876; from the Secretary of the State of Illinois; and from the Davenport (Iowa) Academy of Natural Sciences, Sept. 15th, desiring complete sets of Transactions and Proceedings.

A letter was received from Mr. C. A. Kesselmeyer, 1 Peter Street, Manchester, England, presenting a copy of his Card Calendarium.

Donations for the Library were received from the R. Belgian Academy; French Ministry of Public Works; Annales des Mines; Nature; Linnean Society; Society of Antiquaries; R. Geological Society of Ireland; Silliman and Dana; Editors of the American Library Journal and Medical News; Buffalo Society of Natural Sciences; and the Davenport Academy of Natural Sciences.

Professor Houston made an exhibition of a new telegraphic machine called a "Pneumo-dynamic Relay Sounder," where the local battery is replaced by compressed fluid, and explained it by a working model and diagram. Attached to the armature is a bent lever, with a valve mechanism opening and closing a conduit leading from a reservoir of condensed air. The issuing air swells out a diaphragm of rubber cloth covering a space of one sixty-fourth of an inch, and moves a disc, which moves the striking lever, the return stroke being effected by a spring. The balance of the valve is so adjusted as to diminish for opening the valve. This is affected by an accessory diaphragm pressing upon the other arm of the bent lever; the tension is then equal to the adjusted difference. The instrument works with rapidity enough to get responses easily to thirty-six beats per second.

Pending nominations Nos. 804, 805, 806, 807, and new nomination No. 808, were read.

On motion of Mr. Gabb, the committee on Dr. Valentino's paper was requested to report at the next meeting.

And the meeting was adjourned.

Stated Meeting, October 20th, 1876.

Present, 20 members.

Vice-President, Mr. FRALEY, in the Chair.

Letters of acknowledgment were received from the J. V. N. in Würtemberg, dated Stuttgard, June 24th (complete set of T. & P); the Swiss Society at Berne (92–96), and Professor C. E. Anthon, dated New York, Oct. 19.

Letters of envoy were received from the Swedish Academy, Stockholm, July, 1876; Royal Saxon Society, Leipzig, June 1; Swiss Society, Berne; and Royal Belgian Academy, Bruxelles.

Donations for the Library were received from the Academies at St. Petersburg, Stockholm, Copenhagen, and Bruxelles; the Observatories at St. Petersburg, and Prague; the Geological, Geographical, Zoölogical, and Meteorological Institutions at Vienna; the German Geological Society, Berlin; the Saxon Society at Leipzig; the Societies at Stuttgard, Ulm, Bern, and Lyons; M. de Koninck at Brusselles; the Geographical and Antiquarian Societies at Paris; the Geographical Society, the Victoria Institute and Nature, London; the Glasgow Philosophical Society; Melbourne Inspector of Mines; Canadian Journal; Essex Institute; Boston Nat. Hist. Society, and Massachusetts Commission to the Centennial; Cambridge Museum; American Antiquarian Society; Franklin Institute; Penn Monthly; Journal of Pharmacy, American Journal of the Medical Sciences; and Engineer Department of the United States Army.

Donations for the Cabinet were reported from Professor Guyot, of copies of original antiquities in the Museum of Princeton College, made by Professor Matile, who, with these copies, returned to the Cabinet the originals loaned to him from the Poinsett collection, having made copies of them for the Princeton Museum. Other originals were then selected to be copied and returned in due order.

The Secretary, in exhibiting these donations, said that they

were copies of prehistoric remains: snakes, tortoises, and other bizarre figures, found in Porto Rico.

He had suggested to Professor Matile that certain duplicates in the Poinsett collection might be exchanged for duplicates in the Princeton collection. Mr. Matile and Mr. Guyot subsequently requested that the Society would consider a request for such exchanges; Mr. Matile selected duplicates; and the Secretary displayed specimens of the selection to show in what form the exchanges might be effected.

The death of Sir William Jardine, and Dr. John Hughes Bennett, of Edinburgh, members of this Society, was put on record, the Smithsonian Institution having returned copies of the Proceedings so marked.

The Committee on Dr. Valentino's Memoir reported that they considered it advisable to return it to the author for certain emendations, which, on motion, was so ordered.

Dr. Genth reported his discovery of a new mineral, the telluride of mercury, in the Keystone Lode, Magnolia District, Colorado. Further investigations are in progress and will be reported. The ore contains no silver. Native mercury is said to have been noticed in the mine. *

Pending nominations 804, 805, 806, 807, 808, and new nominations 809, 810, 811, 812, were read.

Ballots were then cast for Nos. 804 to 808.

The subject of providing additional conveniences for the members in the rooms of the Society was referred to the Hall Committee with power to act.

The formal application of Mr. Wooten for the premium of $500 for inventing a successful method of using anthracite slack was referred to the Officers and Council.

On motion, the subject of exchanges of duplicates with the Princeton Museum was referred to the Curators, with instructions to report their action at the next meeting.

Mr. Lesley communicated the fact of experiments being made at Johnstown, by order of the Geological Commission, to obtain some reliable facts about the conduct of mixed an-

* Dr. Genth has named the new species *Coloradoite*.

thracite and bituminous slacks, with and without pitch, in the coke oven.

Mr. Briggs urged the need of circumspection in offering and decreeing premiums to inventors before continuous and complete success; and instanced the use of all the anthracite slack in the manufacturing establishments of New England for the last twenty years, by a variety of methods, all of them successful. In respect of the mixed anthracite and bituminous slacks his experience had been that their combined clinkers were so much worse than the clinkers from either one separately that the mixture could not be used in the fire box.

The meeting was adjourned after scrutiny of the ballot boxes by the presiding officer, who declared the following persons duly elected members:

Mr. Samuel Davenport, of Adelaide, Australia.
Dom Pedro d'Alcantara, Emperor of Brazil.
John F. Hartranft, Governor of Pennsylvania.
Mr. W. Milnor Roberts, of New York.
Mr. Aug. R. Grote, Director Mus. Buffalo S. N. H.

Stated Meeting, November 3rd, 1876.

Present, 13 members.

Vice-President, Mr. FRALEY, in the Chair.

Letters accepting membership were received from Mr. Samuel Davenport, dated Main Cent. Building, Phila., Oct. 26; Mr. A. R. Grote, dated Buffalo, New York, Oct. 26; Mr. John Johnston, dated 812 Broadway, N. Y., Oct. 31, 1876.

A letter from Professor Jos. Henry, dated Smith. Inst. Washington, D. C., Oct. 27, requested a set of Transactions for the Wellington Museum, in New Zealand, under the charge of Dr. Hector, Director of the Geological Survey. On motion the request was granted.

Donations for the Library were received from Mr. Levi Capron (Kaiticushi, Tokio, Japan); the Academies of Ber-

lin and Brussels; the Societies at Ulm and Bath; the Geographical Society and Meteorological Office; and Nature; the Mass. Hist. Soc.; Silliman's Journal; Penna. Historical Society; Penn Monthly; Librarian of Congress; Kentucky Geological Survey; Mexican Geographical Society; Professor R. S. McCulloch and Mr. Samuel Davenport, of New Holland.

A circular letter from Dr. Aug. Le Jolis, dated Cherbourg, Oct. 12, respecting the 25th Anniversary (Dec. 30), of the Society of Science, was on motion referred to the Secretaries to be suitably answered, after being signed by the President.

A communication, entitled "On the Atmosphere of the Sun and Planets, by David Trowbridge, A.M.," (Professor at Waterburgh, Tompkins Co., N. Y.) was received from Professor Kirkwood, of Bloomington, Ind.

Professor Chase made a verbal communication of his views respecting intramercurial bodies revolving around the Sun.

Mr. Briggs described the difficulties in the way of a successful discussion of the type form of the *vena contracta* in hydraulics.

Professor Houston continued the topic, and added remarks upon the nature of the form and movements of the "ventral segments," especially in cases where musical vibrations were employed to effect them.

Pending nominations Nos. 809, 810, 811, 812, were read.

The curators reported, recommending the proposed exchange of duplicates with the Princeton Museum. The report was accepted and adopted.

And the meeting was adjourned.

Stated Meeting, November 17th, 1876.

Present, 17 members.

Vice-President, Mr. FRALEY, in the Chair.

Mr. W. Milnor Roberts, a newly elected member, was introduced to the presiding officer and took his seat.

A letter accepting membership was received from Mr. W. M. Roberts, dated, Bristol, Pa., Nov. 5, 1876.

Letters of acknowledgment were received from the Foundation Teylor, Harlem (95, 97), and the Danish Academy at Copenhagen, Oct. 17 (95).

A letter of envoy was received from the Board of Commissioners of the Second Geological Survey of Pennsylvania, Harrisburg, Nov. 16, 1876.

Donations for the Library were received from the Editors of the Mining Survey of Melbourne; the Academies at Vienna and Copenhagen; the Society at Lausanne; the Revue Politique and London Nature; Mr. Scudder, of Boston; Mr Packard, of Cambridge; Yale College; Professor E. D. Cope; Editors of the American Chemist; Medical News and Journal of Pharmacy; Franklin Institute; the Geological Survey of Pennsylvania; and the Department of the Interior.

On motion, the bill of Mr. Hall for repairs of the roof was ordered to be paid.

On motion, the Librarian was authorized to exchange the Proceedings for Poggendorff's Beiblätter.

The death of Judge Walter A. Lowrie, at Meadville, Nov. 14th, aged 69, was announced by Mr. E. K. Price.

A communication, entitled "Remarks on the Tonkawa Language" by Mr. Albert S. Gatschet, was presented by Dr. Brinton, with a personal notice of the author, well-known for his work on the geographical nomenclature of Switzerland. He was connected with Von Ruprecht and others on the Wheeler Expedition, and has a book in the Weimar press describing twelve Indian languages of the Southwest. The materials from which he has made the well-written and valuable communication to this Society are all original or unpublished.

Dr. Cresson exhibited a bottle of nauseous smelling well water from near Trenton, N. J., which his analysis showed to contain no animal organic impurities, although a cesspool stood at the distance of two hundred feet; but about one

hundred pounds of vegetable organic impurities (in the million gallons) derived no doubt from a marsh situated higher up the slope of the hill, and about a quarter of a mile off, or from truck farms in the same direction a half mile distant. The drainage seems to break down, through the loam and clay cover, into the rock, and find its way by the bed-plates or cleavage-planes to the well.

Professor Frazer adduced an instance where the water of a well at least forty feet above the level of the Jenny Jump Mountain Great Marsh, in Northern New Jersey, was made poisonous in hot dry seasons especially, by the upward percolation of marsh water.

Dr. Cresson said that in the dryest times the subsoil on the heights of Broad Mountain in Schuylkill Co. Pa. was always kept damp by upward percolation.

Professor Frazer described his observations at a recent visit to the Bamfordville Zinc Works in Lancaster Co. Pa. a mile east of Landisville, superintended by Mr. Spilsbury. The deposit is of great interest to the geologist as well as profit to the owners. Instead of being a carbonate, or silicate, or mixture of these two species of zinc ore, as at Saucon near Bethlehem, and in the Western States, it is a sulphide, a very light yellowish brown zincblende, sometimes quite colorless.

He described the process of treating the ore by crushing; bolting into four or five grades of fineness; jigging, or as to the finest grade buddling; and immediately roasting while wet, fresh from the jig. By using the *wet* material Mr. Spilsbury claims that he desulphurizes more readily. The roasted ore is then retorted with fine anthracite dust, and to the mixture Mr. Spilsbury adds 1 to 1. 5 per cent of salt, claiming to get thereby 5 to 6 per cent more zinc from the ore than he could without the use of the chloride. Professor Frazer was desirous of obtaining the opinions of experts on the two points thus observed.

[*Continued on page* 333.]

Silver Louis of Fifteen Sous, struck under Louis XIV., for Circulation in French America.

By Charles E. Anthon, LL.D.,

PROFESSOR OF HISTORY AND BELLES-LETTRES IN THE COLLEGE OF THE CITY OF NEW YORK.

(*Read before the American Philosophical Society, July 21st*, 1876.)

Description—Silver. LVD · XIIII · D · G · [Mint-mark, Sun in splendor, the badge of Louis XIV.] FR · ET · NAV · REX · (Louis the 14th, by the grace of God, King of France and Navarre.) Bust of Louis XIV., laureate, to the right, in corselet and mantle; margin serrated. *Rev.* GLORIAM · REGNI · | TVI · DICENT · ("They shall speak of the

glory of thy kingdom,") 1670. On a crowned shield, three *fleurs-de-lis* (two and one). Above the crown, a crowned A; beneath the shield, between the dot after REGNI and the dot before TVI, A (for Paris, the place of striking); margin serrated. Size 13, scale of the Philadelphia Numismatic Society, *i. e.*, thirteen-sixteenths of an inch. Condition, barely circulated.

Although there has existed among us, for the last quarter of a century, a very considerable degree of interest in the subject of our pre-revolutionary coinage, and although the taste for collecting and studying such specimens of it as can be procured has steadily increased, till the majority of the rarer and more remarkable pieces extant have found their way into the cabinets of collectors, to the great enhancement of the price of those which remain in the market, and with a corresponding whetting of the appetite to possess them on the part of antiquarians, it strangely happens that the beautiful coin represented above, demonstrably American, and suggestive of important historical remembrances as it is, has remained neglected and unsought for. No author on American Numismatics seems to have been aware of its existence until the present writer, in Vol. IV., No. 9, for January, 1870, of the American Journal of Numismatics, which he then edited, called the attention of its readers to the fact. A brief and unsatisfactory notice of it, not founded, as is confessed, on actual inspection, forthwith appeared in Sandham's "Supplement to Coins," &c., of Canada, Montreal, 1872; the main work, published in 1869, being silent on the matter. But Mr. Sylvester S. Crosby, of Boston, who has lately (1873–1875) produced the last and best work on the general subject, entitled, "The Early

Coins of America, and the Laws governing their Issue," and proves himself, on every page of it, to be a diligent and conscientious laborer, thinks himself called on to adopt an apologetic tone when mentioning this piece, and to speak of it as "not strictly included in our original plan." Yet his purpose, or "original plan" was, in his own language, "to give all the trustworthy information at" his "command, relative to such coins, or tokens, which were intended to serve as coins, that were either struck in those parts of America which now constitute the United States, or were intended for use therein;" and it cannot be controverted that this is the earliest official coin of a region embracing at least half of the States which now constitute the Union. We are not perhaps, in general, sufficiently alive to the truth that, from the Atlantic to the remote West, the beginnings of colonization were chiefly made by France. Not Canada and Louisiana, merely, formed the French America of a once far from improbable future. In an authority easy to consult, Bancroft's History of the United States, Vol. II., we find a "Map of French, English, Dutch, Swedish and Spanish possessions, or claims in the United States, in 1655." A narrow strip from the Kennebec to Cape Fear, is all that is marked as not French, to the northward of Florida. A large part of Maine, all West Virginia, South Carolina, Georgia, the greater part of New York and of Pennsylvania, and from these all westward, as far as exploration had then extended, are French. Every one of the States comprehended within the area thus roughly denoted, may regard the coin in question as its earliest monetary relic.

Without, however, going back to years anterior to its date, or looking away from the broad double valley, which extends between the Alleghanies and the Rocky Mountains, or including States of which any portion lies outside of these limits, we can easily, we think, form a list of fifteen, in each of which the collector, present and to come, must regard this "Gloriam Regni" of 1670, as its most ancient numismatic monument. The reader of history is aware that "Louisiana" was, in 1712, defined by authority as comprising all the country drained by waters emptying directly or indirectly into the Mississippi; while the schoolboy has been taught that, out of the "Louisiana purchase" of 1803, alone, have already been formed fifteen States and territories, eight of the former and seven of the latter. Since it happens that, in the article already referred to (American Journal of Numismatics, Vol. IV., No. 9, for January, 1870), the present writer, just two centuries after the first appearance of this coin, introduced it to American collectors as a new "Colonial," not known to them before, and proper to take the place usurped by one familiar to the numismatic fraternity under the name "Louisiana copper," or "R F," he must now again insist on the correctness of this view, and re-affirm that the GLORIAM REGNI is the earliest colonial coin of at least half the States of the Union. Of course we do not mean that it actually circulated in the whole vast region mentioned; but it may have appeared accidentally in any part thereof, and, wherever it did so appear, it was, in the

estimation of any Frenchman who might behold it, the coin of the realm which he trod.

It is, then, our oldest French "Colonial." Mr. Crosby may boldly represent it as such in his next edition. No apology will be required. Both he, indeed, and his predecessors, needed rather to defend (as he attempts to do), or, in fact, avoid altogether, the introduction of the "Sommer Islands," (or Bermuda) patterns for shilling and sixpence, in a work on the coinage of the United States, where they can have no just claim to stand.

With a few brilliant exceptions, our prominent numismatic collectors, and even authors, have not been men of much research or of a wide range of reading. They have delved with greater or less industry in a narrow field; and authorities, other than those in English, have not occurred to them. Hence works of some rarity, like Le Blanc's Treatise on the Coins of France, or of great commonness, like the New France of Charlevoix, which latter, as we shall soon proceed to show, contains most satisfactory corroboration of the American character of the coin of Louis Quatorze before us, with a tolerably ample history of it, have equally escaped their notice. As John Smith's History of Virginia, on the other hand, includes a full account of the Sommer Islands pattern, and is a familiar book, in English, they have, through a natural confusion of localities, inadvertently come to regard that coin as a United States "Colonial" one.

Moreover, this GLORIAM REGNI, or French-American piece of Fifteen Sous, is a very rare coin. I infer from the first of the two French authorities whom I have named—and I shall presently quote his exact words—that only one hundred thousand livres' worth of 15-sous pieces and 5 sous pieces, together, was struck in 1670, and none at any subsequent date. The "livre," now obsolete, was one-eightieth less in value than the present franc, and, like the franc, contained twenty sous. Personally, I know of the existence of only five specimens. I have had the good fortune to obtain two, both in very fine condition, from two different auction-sales of coins in Europe, and one of these I have now the honor of presenting to the American Philosophical Society, with an accompanying wood-cut made expressly for the illustration of this paper; a third, seemingly in a poor state of preservation, if we may judge from its heliotype likeness in Mr. Crosby's work, plate III, No. 5, is in the cabinet of that accomplished scholar and numismatist, William S. Appleton, of Boston; the fourth had, from its appearance, and the locality where I met with it, in all probability been circulated in America. It was in the collection of Mr. J. Myshrall, at Frederickton, New Brunswick, where I saw it in 1870, towards the end of the summer. It showed marks of rough treatment, and must, I think, in passing from hand to hand, have reached, from Lower Canada, the town where it came under my observation. The fifth has been shown me since I began to write this communication, by its owner, Mr. Henry Mott, at present of Brooklyn, but formerly of Montreal.

It bears slight marks of circulation, and was obtained in the latter city. Hence it too, probably, was once in actual use.

And here I have a remark to make: that it is a somewhat unreasonable, albeit almost universal, trait of collectors of coins, to strive to obtain them in a condition, if possible, uncirculated, or at least nearly approaching that state. Yet it is evident that marks of actual service, provided they have not obliterated the legend or seriously impaired the device, ought to give a heightened interest to these objects, as proving them to have been handled by the people of their time. The desire to possess a collection, which, in mechanical and artistic beauty and brilliancy, may compare favorably with others, seems, however, to transcend, with most numismatists, every other consideration; and accordingly a coin, which may be called still-born, inasmuch as it has, by some accident, been snatched from a coin's virtual existence, which is its circulation, on the very threshold of such real life, has always commanded, and will continue to command the preference.

But it is now time to authenticate our GLORIAM REGNI, and establish, by evidence, that it is entitled to the estimation which we claim for it. In the "Historic Treatise on the Coins of France, from the commencement of the Monarchy to the present time," by Mons. Le Blanc, Paris, 1703, we read at page 388: "In order to facilitate commerce in Canada, the King caused to be struck a hundred thousand livres' worth of Louis of 15 sous, and of 5 sous, and Doubles of pure copper. These coins were of the same value, weight, and fineness with those of France. On the silver Louis of 15 sous and 5 sous, in place of the *Sit nomen Domini benedictum*, there was *Gloriam regni tui dicent*, and on the Doubles, *Doubles de l'Amerique Françoise*." The specimen which I transmit to the Society, must therefore, as its size and intrinsic value denote, be one of those of Fifteen Sous. I am much inclined to doubt whether the Louis of five sous was really struck, since I have never seen one or heard of one as actually existing. Nor is any "Double" to be found, as far as I know, among American collectors, though the inhabitants of Lower Canada and of the French West India Islands have in all likelihood preserved some few examples. Mr. Crosby's heliotype portrait of the piece, plate III, No. 6, is as he informs us, not taken from a genuine one.

In a letter written at Quebec, Feb. 15, 1721 (Nouvelle France, Vol, III, p. 91), Charlevoix gives us the following information on our subject: Commerce in Canada was depressed by nothing perhaps more than "the frequent changes which were made there in the coins. I will give a brief account of the matter. In 1670, the West India Company, to which the King had ceded the dominion over the Islands of the French American Continent, had permission to introduce into the Islands small money to the amount of a hundred thousand francs, stamped by a particular die, with a legend which was peculiar to it. The King's edict is of the month of February, and was to the effect that these coins should be current only in the Islands. But on certain difficulties, which supervened, the Council

issued, on the 18th of November of the year 1672, a decree by which it was ordered that the money aforesaid, and all other specie, being current in France, should also be current, not only in the French Islands but also on the terra-firma of America subject to the crown, with an augmentation of one-fourth superadded; that is to say, the pieces of fifteen sous for twenty, and the others in proportion."

"The same decree ordered that all contracts, bills, accounts, purchases and payments should be made between all descriptions of persons, in money, without privilege of barter or accounting in sugar, under penalty of nullity as to transaction. And in regard to the past, it was ordained that all stipulations relating to contracts, or bills, or debts, or obligations, or rents in sugar and other provisions should be reduced into and made payable in money, at the valuation of the aforesaid coins. In execution of this decree, coin increased one-fourth in value in New France," &c., &c. Here we leave the amiable Jesuit to relate the financial mischief which ensued, and we quit the historic aspect of our theme for the æsthetic and literary.

As a work of art this coin is beautiful. It will, from that point of view, compare advantageously with any now produced in the home-mints of this country, where it was once intended to circulate. The portrait of Louis presents him as a handsome man of thirty-two, his age in 1670; the mint-mark of the sun in splendor recalls his famous motto: "*Nec pluribus impar*"—which, by the way, has a structural similarity to our own national one;—the manner of marking with a · subscript the final I in XIIII is very uncommon; I know no other instance of it on a coin. The reverse offers us, as a subject of remark, first, the legend: "*Gloriam Regni tui Dicent.*" It is taken from the vulgate of the fine Psalm CXLV., entitled "David's Psalm of praise." Verses 10–13 of our translation read as follows:

10. All thy works shall praise thee, O Lord; and thy saints shall bless thee.
11. *They shall speak of the glory of thy Kingdom*, and talk of thy power;
12. To make known to the sons of men his mighty acts, and the glorious majesty of his Kingdom.
13. Thy Kingdom is an everlasting Kingdom, and thy dominion endureth throughout all generations.

In the application of the beginning of verse 11 to the purpose of a numismatic legend, particularly if it be considered in connection with its context, two covert references seem to me to be intended; the first, to the highly ecclesiastical character of French colonization in America, in which exploration and conversion ever proceeded hand in hand; the second, to the "mighty acts" and "glorious majesty" of the "grand Monarque." It is true that he had not, at this comparatively early epoch in his reign, put forth the exaggerated pretensions which he afterwards advanced; but the adulation and irreverence which offend us in the use made of these words, were already in the taste and fashion of that day.

Our second subject of remark is the crowned A (such we take it to be) which appears above the royal crown which forms the armorial crest. In

the absence of any authoritative information on the subject, we may reasonably conjecture that it signifies French (or Royal) America, and, if this be so, the only characteristic needed to make this coin pre-eminent in interest among all American colonial pieces, that, namely, of having on its face a distinct mention of our Continent, is supplied.

In concluding this paper, of which the subject, and the treatment of the subject, will, it is hoped, not be found beneath the notice of the American Philosophical Society, the writer may be permitted to observe that the fact of its being presented in this our year of Jubilee, and at the moment whence, a century ago, our first grand "annorum series" began to proceed, is entirely accidental, resulting from the casual acquisition, at this time, of the specimen which accompanies it. There seems, however, to be an eminent propriety in calling to mind, on the present most interesting occasion, and also connecting with tangible objects of curiosity, however slight, the American history of the great ally who rendered such essential aid to the insurgent colonies during their doubtful struggle. In regard to matters like this, perhaps not likely to be remembered with sufficient tenacity, medals and coins perform an important service; while, to take a broader view, through their distinct marking of decisive epochs, they contribute to enable us, in the words of a writer of the illustrious nation referred to, "*vivre de la grande vie des siècles*"—to live in the great life of the Centuries.

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*On some Fundamental Propositions of Central Force.**

By Pliny Earle Chase, LL.D.,

Professor of Philosophy in Haverford College.

(*Read before the American Philosophical Society, July* 21, 1876.)

All cyclical motions which are produced by the action of a central force are, necessarily, of an oscillatory character. They may, therefore, be mathematically represented by suitable modifications of simple pendulum equations, as Fourier has well shown.† The first attempt at a general discussion of such motions seems to have been made in 1827, by Dr. Henry James Anderson, Professor of Mathematics and Astronomy in Columbia College, whose paper‡ may be found in the third volume of the second series of the

* Whenever I speak of "central force," in the present paper, I refer to force varying inversely as the square of the distance.

† See, also, papers by David Rittenhouse, Trans. Soc. Phil. Am., iii; Jos. Clay Ib., v; Owen Nulty (suggested by Rittenhouse's), Ib. [2] i; James Dean, and N. Bowditch, Trans. A. A. S., iii; Robert Adrain, Trans. S. P. A., [2] i; Eugenius Nulty, Ib. [2] ii.

‡ "On the motion of Solids on Surfaces, in the two Hypotheses of perfect Sliding and perfect Rolling, with a particular examination of their small Oscillatory Motions." *Op. cit.* p. 315.

American Philosophical Transactions. The following quotation from his exordium is both prophetic and suggestive :

"There are few branches of Mechanical Philosophy as interesting in every point of view as the theory of Oscillatory Motion. From the minutest vibrations of a harp-string to the magnificent oscillations of a planet's axis, there are an infinite number of analogous phenomena remarkable for their curious properties or important uses. The common pendulum, that little instrument which has rendered such essential service to science and the arts, and will soon, in the hands of the skilful observer, unfold to us the internal constitution of our globe, and give a clue to the process by which it has acquired its present state, is itself indebted for its accuracy to the incessant superintendence of a watchful mathematical analysis. The science of Acoustics in all its parts, the varied phenomena of the tides, the theory of Saturn's ring, that wonder of the solar system, and the philosophical explanations of the stability and harmony of the celestial motions, are in fact, but different applications of this extensive branch of Demonstrative Mechanics. What adds to the interest and value of this subject is the circumstance that a large class of oscillatory motions, namely those of any rigid system whatever whose points depart but little from the position which they occupy when at rest, has been found susceptible of complete determination, by means of which the position of the bodies composing the system may be expressed (to use the language of analysis) in finite functions of the time."

In 1843, Professor Stephen Alexander communicated to the American Philosophical Society,* his observations upon physical phenomena which accompany eclipses. Among those phenomena was a "dragging of shadows," which he attributed, at the first meeting of the American Association (Philadelphia, 1848), to the inertia of the luminiferous æther. By this, and other like "scientific uses of the imagination," he was led to the discovery of a series of cosmical relations, some of which were laid before subsequent meetings of the Association, the whole being finally embodied in his "Statement and Exposition of Certain Harmonies of the Solar System."†

At the second meeting of the American Association, (Cambridge, 1849), Professor Benjamin Peirce read a paper "On the Relation between the Elastic Curve and the Motion of the Pendulum." "On this subject Prof. Peirce remarked, that the relations discovered merely by intellectual investigations, and not observed by the senses, are of peculiar interest, as manifesting the fact that one intellect presides over the production of those phenomena. Could we see in the moon a house like our own, we should say that it was built by men like ourselves, having similar wants, and using similar means to supply them, and we should say that the same being who formed our minds created theirs also. We cannot make such observations, but we may trace relations between objects with which we are

* Proc. Soc. Phil. Amer., May, 1843, vol. iii.

† Amer. Nat. Acad. Sci., 1873-4; Smithsonian Contrib., 280.

familiar, which lead us to similar results. At present the discovery of these relations has been very much confined to those subjects to which mathematics apply."* At a later session of the same meeting, Peirce presented a "Mathematical Investigation of the Fractions which occur in Phyllotaxis." After showing the influence of an identical law in the arrangement of plants and planets, he asks: "Whence could this extraordinary coincidence have arisen but from the action of a single mind? and what does it indicate but that the same Word which created the planet, is expressed in the planet? May I close with this remark, that the object of geometry in all its measuring and computing, is to ascertain with exactness the plan of the great Geometer, to penetrate the veil of material forms, and disclose the thoughts which lie beneath them? When our researches are successful, and when a generous and heaven-eyed inspiration has elevated us above humanity, and raised us triumphantly into the very presence, as it were, of the Divine intellect, how instantly and entirely are human pride and vanity repressed, and by a single glance at the glories of the infinite mind, we are humbled to the very dust."†

On the second of January, 1849, in a communication "On the Fundamental Principles of Mechanics,"‡ Peirce had already shown that "a system of bodies in motion must be regarded mechanically as a system of forces or powers which is a perfect representative of all the single powers of which the system is compounded, and this, too, at whatever time or times the component powers may have been introduced into the system. The question of the simultaneous introduction of the partial powers is of no importance. Any power which is at any time communicated to the system is preserved in the system unchanged in amount or direction."

At the same meeting of the Academy, Professor Joseph Lovering read a paper "On the Law of Continuity,"§ in which he said, "the method of analysis which began with Leibnitz and Newton, and which in England has been known under the name of fluxions, rests upon this law of continuity. If we admit the usefulness of the principle only in cases of motion, we still give it a wide range; since so many problems, not strictly dynamical, are reduced to cases of motion when investigated by the rules of modern analysis."

On the 4th of Feb. 1851,‖ "Professor Peirce gave an argument, which he thought to be new, against the principle which is usually adopted in theoretical works, that the force of a body in motion is its *vis inertiæ*. He believes, on the contrary, that the time is at hand when the *vis viva* will be universally recognized as the force of a moving body. His new argument is derived from the effect of a force in causing rotation, as well as translation. By the old theory, no additional force is required to produce rotation; whereas, by the theory of the *vis viva*, just as much force is re-

* Proc. A. A. A. S., ii, 129.
† Ib., p. 446.
‡ Proc. A. A. S., ii, 111.
§ Ib., p. 121.
‖ Ib., p. 256.

quired as is actually exhibited in the resulting rotation. The same argument may be derived in another form from the vibrations of elastic bodies."

The "Mathematical Monthly," for January, 1859, contained an exhaustive discussion of "The Motions of Fluids and Solids relative to the Earth's surface," by Professor William Ferrel, some of the results having been published about two years before, in the "Nashville Journal of Medicine and Surgery." The recent great advance in meteorological knowledge and in successful weather prediction is due, in great measure, to the publication of Ferrel's laws.

In 1861, Professor Simon Newcomb presented to the American Academy, a compendious review of the dynamical theory of gases.* His paper contains, among other matters of interest, the following first approximation towards a theoretical establishment of the empirical ratio between the temperatures under constancy of pressure and under constancy of volume: "7. If the particles were perfectly hard and spherical, the specific heat under constant volume would be to that under constant pressure as 3 to 5. If they were hard, but not spherical, this ratio would be that of 3 to 4. The latter result follows from an elegant theorem given by Professor Maxwell in Vol. XX, of the Philosophical Magazine, viz., that if the particles are hard, but not spherical, the sum of their *vires vivæ* of translation will be equal to that of their *vires vivæ* of rotation."

My first attempt at applying the foregoing principles was made in 1863,† when I showed that the daily fluctuations of the barometer are of such form and magnitude as can be explained by the combined action of atmospheric inertia, terrestrial resistance, and *motion* relative to the Sun. I also showed that the tendencies to equality of areas, in the daily and yearly fluctuations, furnish the data for a close approximation to the solar distance.‡

In 1864, Professor James Edward Oliver made a practical investigation of the best approximate representation of all the mutual ratios of k quantities by those of simple integers, drawing illustrations especially from phyllotaxis and planetotaxis. His investigation assumed that "Nature, while obeying with absolute precision the resultant of her efficient laws, such as Inertia, Attraction, etc., falls into forms which commonly both *utility* and *taste*, often independently of each other, would prescribe."§

In 1865, Ferrel described an annual variation in the daily mean level of the ocean, the greater part of which he attributed to "a tangential force arising from the motions of the ocean combined with the motion of the Earth's rotation. It was first brought out in its most general form in [his] paper on the motions of fluids and solids relative to the Earth's surface."‖

* Proc. A. A. S., v, 112.

† Proc. Soc. Phil., Amer., ix, 283.

‡ Ib., *loc. cit.*, and x, 376. See, also, Ferrel's paper of 1865, to which reference is made below.

§ Ib., vi, 288.

‖ Ib., vii, 35.

A few days ago, Dr. Thomas Hill, Ex-President of Harvard College, illustrated the danger of exalting science above philosophy. "The true aim of science is not merely to record the uniformities of nature, but to discover the intellectual ideal which binds them together. The human mind in the presence of phenomena * * * is always inclined to ask three questions: What is the invariable order of sequence? What cause produces the effect? For what end are they produced?"*

Each of these papers involves one or more of the following postulates, which are treated by many as scientific heresies, but which others regard as prolific truths.

1. Faith and Reason are both handmaids of Science.

2. Knowledge is not only power, but it is also supreme power, or the source of all power.

3. Order and harmony are evidences of Intelligence. The discovery of new harmonies should, therefore, always stimulate new scientific investigation.

4. There can be no law without a Lawmaker.

5. Unity of Intelligence indicates unity of law.

6. Æsthetic gratification points to efficient laws.

7. All empirical results rest on *a priori* principles.

8. The methods, are permanently recorded in the works, of Intelligence.

9. There can be no unbalanced physical force without motion Even forces which are *relatively* static, can only be fully studied when producing motion.

10. Simple physical force is always central. Therefore the laws of elasticity and of oscillatory motion are of prime importance in all fundamental physical investigations.

11. Any æthereal medium, through which impulses are progressively transmitted, must be material.

12. Any medium through which impulses are transmitted instantaneously,† must be devoid of inertia, and therefore spiritual.

13. Tendency of motion is always in the direction of least resistance. Radial and tangential oscillations naturally alternate.

14. If the force of a moving body is its *vis viva*, the average *vis viva* of a perpetual oscillation is the proper standard for determining its quantity of motion, and the average velocity is the velocity of an equivalent synchronous oscillation under uniform velocity.

Most of these postulates, like all hypotheses, theories and laws, fall within the domain of metaphysics. Physical science, properly so called, is limited to facts which are discoverable by the senses, and to their co-ordination in accordance with metaphysical requirements. Pure metaphysics tends to

* Address before the Alumni of Bowdoin College, July 12, 1876.

† The only instance of supposed instantaneous transmission is that of gravitating action. La Place's estimate of its least possible velocity has been variously and sometimes wrongly stated; in his *Mécanique Céleste*, X, vii, 22, he fixes it at 100,000,000 times the velocity of light, and says, "therefore mathematicians may continue to regard it as infinite."

dreaminess and paradox ; pure physics, if such a thing were possible, to worldliness and shallowness. Metaphysics strives to learn too much ; physics is satisfied with too little. Science deals both with the physical and with the metaphysical ; embracing all knowledge that bears, in any way, upon the religious, the ethical, or the intellectual needs of man. An exclusive regard to either phase of our triune nature leads, almost of necessity, to shortsightedness and narrowmindedness. In the modern science of thermodynamics, the fertility of discovery, which has rewarded the labors of European and American investigators, furnishes abundant evidence of the usefulness of metaphysical anticipations as aids to physical research.

Newton looked to æthereal oscillation as a probable source of gravitation, finding it easier to imagine the approach of inert bodies through the influence of elastic thrusts, than to conceive of any practicable form of pull; Le Sage, adopting Newton's view, developed it with considerable detail, and later French Academicians have shown, in various ways, and to various extents, the likelihood of the hypothesis ;* Anderssohn has given an experimental demonstration of its sufficiency ; Norton and Challis have engaged in similar speculations, which they have extended so as to embrace all known forms of force ; Weber, Kohlrausch, and Clerk Maxwell have confirmed Faraday's partial identification of light and electricity by actual measurement ;† Faraday's cautious suggestion of "lines of force," proposed to treat all forces mathematically and independently of any hypotheses as to their nature, a proposal which has been largely and wisely followed by many recent investigators. As a further contribution towards such treatment I submit the following propositions, to which I have been led in the progress of my own researches, and which may be serviceable in other investigations.‡

Let f — velocity communicable, at distance r in time t, by any central force varying inversely as r^2.

f' — velocity communicated by a single impulse or in a single instant.

f_i — if' — " " by i equal impulses, or in i instants if the distance remains constant. Then

I. If the pressure resulting from f is constant, it must either be exactly

* For some of the most important of these papers, see references of W. B. Taylor, in Journal of the Franklin Institute, cii, 71.

†The 9th postulate may, perhaps, be made still more general by this measurement. That we know no instance of absolutely static force, is indisputable ; the communication of momentum or *vis viva* by any physical agency which has no momentum nor *vis viva* is, to me, inconceivable; the consideration of electrostatic force as force static relatively to the Earth, and of electrodynamic force as force moving with the velocity of light, furnishes almost demonstrative evidence of a universally oscillating æthereal medium which may be the secondary or physical source of all physical motion and all physical force.

‡Most of the propositions of Newton's Principia are applicable to all central forces.

counterbalanced by some opposing force or forces, so as to produce relative rest; or the motion must be maintained at a constant distance from the centre, so as to produce circular revolution; or, if the opposing force results from the transformation of interfering revolutions, the two conditions may be combined so as to produce rotation. The velocity of circular revolution $= \sqrt{fr}$; the velocity of rotation $= \sqrt{fr} \div n$. The value of n may be found by experiment, or, if the aggregating impulses are homogeneous, it may be easily calculated, as will be subsequently shown (V–VII).

II. If the pressure is varying, and so exerted as to produce radial motion, directly towards the centre, the velocity acquired, at any given distance ρ, may be found by the equation $v_\rho = \left\{\frac{2fr(r-\rho)}{\rho}\right\}^{\frac{1}{2}}$. Therefore, if the theory of Boscovich were true, at the centre, where $\rho = 0$, v_ρ would be infinite.

III. If the varying pressure, or pull, leads to perpetual radial oscillations, synchronous with perpetual circular oscillations under constant pressure, or pull, the extent of the radial excursions from the centre is $2r$, and the mean velocity of radial oscillation (Postulate 14) is $\frac{2}{\pi}\sqrt{fr}$. The equation $\frac{2}{\pi}\sqrt{fr} = \left\{\frac{fr\,(2r-\rho)}{\rho}\right\}^{\frac{1}{2}}$* gives $\rho = \frac{2\pi^2 r}{\pi^2+4} = 1.4232r$.

IV. Since the *vis viva* of a moving particle varies as $\frac{1}{r}$, the *vis viva* at the radius of average radial velocity in a rectilinear orbit, : the *vis viva* at the radius of synchronous circular velocity : : 1 : 1.4232.

V. If the constrained synchronous rotation of particles in a spheroid, and the free revolution of exterior particles, are due to the same primitive æthereal impulses (I), the uniform velocity of those impulses is the *limiting* velocity, towards which both motions tend when their circular paths are indefinitely diminished. Let, therefore, $v_1 = \sqrt{fr} \propto \sqrt{\frac{1}{r}}$ = velocity of free equatorial revolution; $v_2 = \frac{\sqrt{fr}}{n} \propto \frac{1}{r}$ = constrained velocity at the same point = velocity of superficial equatorial rotation. Then $v_0 = \left[v_1\right] = \left[v_2\right] = nv_1 = n^2 v_2 = n\sqrt{fr}$ — limiting tangential velocity, both of revolution and of rotation, under a reduction of spheroidal volume to an equatorial radius $\frac{r}{n^2}$. Under such reduction, all the particles in the equatorial plane would have the velocity of free revolution, or of perfect fluidity.

*Since $f \propto \frac{1}{r^2}$, the substitution of $2r$ for r_0 gives $fr\,(2r-\rho) = 2f_0 r_0 (r_0 - \rho)$.

VI. If contraction were to go still further, the centrifugal force of rotation would give the nucleal particles orbits of increasing ellipticity. These orbits would finally become infinite, when the average linear motion was equivalent to parabolic perifocal motion; or, in other words, when the mean linear velocity, $\frac{2}{\pi}\left[v_x\right] - \left[\sqrt{2fr}\right]$. These velocities tend to or from coincidence at $\frac{2r}{n^2\pi^2}$; for $\frac{n^2\pi^2}{2} \times \frac{2}{\pi} \times \sqrt{\frac{fr}{n}}$ $= \frac{n\pi}{\sqrt{2}}\sqrt{2fr} = n\pi\sqrt{fr}$. We thus find that the limiting velocity between complete dissociation and incipient aggregation ($n\pi\sqrt{fr}$), is $\pi \times$ the limiting velocity between complete aggregation and incipient dissociation ($n\sqrt{fr}$; see V.)

VII. Let t — time of describing $\frac{1}{2}r$, in virtual approach to the centre, under the action of any central force f, — time of describing r in circular revolution, or motion under constant pressure. Then $ft = \sqrt{fr}$; πt — time of free semi-circular oscillation; $n\pi t$ — time of constrained semi-circular oscillation — time of semi-rotation; $n\pi ft = n\pi\sqrt{fr}$ — velocity acquired in the time of semi-rotation — *radial limiting* velocity (V, VI). Therefore the velocity of any central impulses which are capable of producing aggregation, free revolution, and constrained rotation — velocity produced by constant equatorial pressure acting for one half-rotation.

VIII. Radial oscillations, through a radius $\rho = mr$, give the central dissociating velocity $\left(\sqrt{2fr}\right)$ at $\frac{mr}{m+1}$.

IX. Undulations in elastic media tend to generate other undulations, in arithmetic, geometric, harmonic and other figurate progressions.

X. The limiting radius of free revolution (or the atmospheric radius in nebular condensation) varies as $t^{\frac{2}{3}}$; the limiting radius of constrained rotation (or the nucleal radius) varies at $t^{\frac{1}{2}}$. Therefore the nucleal radius $\propto$ $\frac{3}{4}$ power of the atmospheric radius. In ordinary discussions of the nebular hypothesis, planetary aggregation has been regarded as atmospheric, under a velocity varying as $\sqrt[6]{\frac{1}{r}}$; but there are many traceable evidences of simultaneous nucleal activity, under a velocity varying as $\frac{1}{r}$.

ILLUSTRATIONS.

Electrodynamics and thermodynamics furnish numerous illustrations of Prop. I, but some of its most obvious exemplifications are found in cosmical revolution, atmospheric elasticity, axial rotation, and in the various applications of Ferrel's laws.

Proposition II identifies all central forces, so far as an identical ideal limit of velocity is concerned. It is true that the ideal limit is physically unattainable, but a full development of Peirce's theory, of *vis viva* and simul-

taneous rotation and transmission,* will doubtless contribute to the proper determination of data for finding the practicable equivalent, in any given case.

According to the dynamical theory of gases, the average radial velocity, which is found by Prop. III, is the velocity which represents constancy of volume, in any aggregation of a homogeneous elastic fluid.

We have already seen (I) that *dynamic* constancy of pressure produces the velocity of circular revolution; and by the principles of thermodynamics, specific heat varies as *vis viva*. Prop. IV, therefore, furnishes an exact mathematical accordance with the empirical ratio between heat of constant volume and heat of constant pressure,† the representative of constant pressure in a perpetual radial oscillation, being the radius of mean excursion; the representative of constant volume, the radius of mean velocity; while the *vires vivæ*, of circular revolution due to constant pressure and of circular revolution maintaining constant volume, are inversely as their respective radii. Newcomb showed‡ that if there is actual collision of particles, they can neither be perfectly hard and spherical, nor hard and not spherical. There must, therefore, be elasticity or something analogous to elasticity, either in the gaseous particles themselves, or in their relative motions. Peirce's views, together with the fact that *vis viva* varies as the quantity of motion, (the quantity of motion, in perpetual oscillation under uniform resistance, being proportional to the average velocity), seem to involve the probability that there is no absolute collision, but the phenomena are due to simple motions, and are independent of the nature of the particles themselves. The *vis viva* of constant circular velocity varying inversely as radius, the product of such *vis viva* by radius, for any given central force, is a constant quantity.§

Prop. V may perhaps prove suggestive, in the study of the mechanical differences between fluidity and solidity, and of the laws of chemical combination, as well as in the elucidation of the nebular hypothesis, of which some illustrations are given below. I have already shown‖ that Alexander's planetary ratio, 1.8, which is the $\frac{5}{7}$ power of the thermodynamic ratio 1.4232, appears in the explosive energy of H_2O, and that this energy is directly traceable to the limiting velocity of synchronous rotation and revolution¶ under the same primitive impulses (I, III).

If the central force f, in Prop. VI, is solar gravity, the limiting velocity $(n \pi \sqrt{fr})$ of uniform impulses which account for solar and planetary

* *loc. cit.*, Feb. 4, 1851.

† The principal estimates of $\frac{c}{c'}$ are: Guthrie, Regnault, 1.41; Masson, 1.419; Tyndall, 1.421.

‡ *loc. cit.*, 1861.

§ The various *vires vivæ* considered in the present paper are:

v. v. of interior nucleal rotation in an unchanging nucleus, varying as r^2;

v. v. at any point within a homogeneously expanding or contracting nucleus, varying inversely as r^2;

v. v. of free revolution communicable by interior nucleal rotation in an unvarying nucleus, varying as r;

v. v. of free revolution due to fall towards, or repulsion from centre, varying inversely as r.

‖ Proc. B. P. A., xii, 394. ¶ Ib., and xiii, 142.

aggregation, solar rotation, and planetary revolution, is *the velocity of light.** For, Sun's distance from Earth being 214.86 solar radii, the velocity of light $= \frac{214.86r}{497.825} = .4316r$ per second. Equating this value with $n\,\pi\sqrt{fr}$ and substituting the value of $\sqrt{fr} = \sqrt{gr} = 2\,\pi\,r \times 214.86 \div (365.2564 \times 86400) = .000627049r$ per second, we find $n = 219.0894$, and $v_2 = \frac{\sqrt{fr}}{n} = .0000028622\,r$ per second. On comparing this result with the estimates from observation of Sun-spots, we find it is about $\frac{3}{5}$ of one per cent. greater than Schwabe's estimate (.0000028511), while it is about $\frac{1}{4}$ of one per cent. less than the average of Spörer's greatest (.0000029533, in lat. 1° 45′) and least estimates (.0000027863, in lat. 24° 38′). All other estimates are embraced within Spörer's limits, and most of them agree very nearly with Schwabe's. Such closeness of exemplification in gravitating action, may well encourage a search for others in chemical association and dissociation.

Inasmuch as Prop. VII is a corollary of Prop. VI, it may be practically illustrated by the same examples. It has, however, an additional interest, by showing that the radial impulses continue their efficiency, within the rotating mass, until they are able to proceed, without interruption, in the same direction in which they entered the system. It also lends confirmation to the above values of n and v_2.

Prop. VIII accounts for the coefficients of planetary distances, in the abscissas of my Stellar-solar parabola† of which I offer a new form in my remarks on Prop. X.

The various planetary harmonies which have been pointed out by Titius, Bode, Alexander, Peirce, Kirkwood, and myself, furnish abundant *a posteriori* corroboration of Prop. IX.

Obermayer's Law (Trans. Vienna Acad.; quoted in *Nature*, June 1, 1876, p. 119), that the friction-coefficient of permanent gases varies as the $\frac{3}{4}$ power of the coercible gases and as the absolute temperature, seems to fall under Prop. X, as a particular case of the nucleal and dissociating influences of central force. The planets furnish various other cases, under the same proposition, illustrating Peirce's views as to the constancy of the quantity of motion, or *vis viva*, in a system, Oliver's æsthetic theorem, my planetary pendulums,‡ and nearly all of the postulates.

The time of terrestrial rotation being 86400 seconds, and the time of free revolution at the equator $(2\,\pi\,r \div \sqrt{gr})$ 5074 seconds, the *vis viva* of revolution is $\left\{\frac{86400}{5074}\right\}^2 = 289.68$ times the *v. v.* of rotation at the same point. If this is the *v. v.* at the limit between complete aggregation and incipient dissociation, the *v. v.* at the limit between complete dissociation and incipient aggregation (VI, VII,) is π^2 times as great. Therefore, if Earth's

* Ib. xi, 103, and subsequent papers.

† Ib., xii, 523.

‡ Proc. Soc. Phil. Amer., xiv, 612, 622, sq.

motions represent *nucleal* formative force, the velocity of rotation at the latter point should be $\frac{1}{\pi^2} \times \frac{1}{289.68} \times \frac{2\pi r}{5074} = .0000004331r$ per second.

We have already seen (V) that the solar equatorial velocity at the lower limit is $\frac{1}{\pi}$ the velocity of light, or $.1374r$. But in perpetual nucleal rotation the communicable interior *v. v.* varies as the velocity, or as radius, and in circular revolution the mass $\propto$ *v. v.* $\times r$. Therefore if we refer the solar and terrestrial motions to the same nucleal radius, we get, for their respective masses, the proportion; Sun : Earth : : .1374 : .0000004331 : : 317,500 : 1. This represents a solar parallax of 8″.924 and a distance of 91,600,000 miles.

Applying a similar test to Jupiter's motions, we find no evidence of nucleal formative action, but a close approximation to atmospheric force synchronous with the Earth-aggregating nucleal force.* The identity of value in the two forces may be shown as follows:

The velocity of revolution, at Sun's equator, is $\frac{2\pi \times 91,600,000}{214.86 \times 10020.24} = 267.3265$ miles per second. If this is the fundamental formative velocity for Earth and Jupiter, Earth's time of semi-rotation (VII) should be $\frac{267.3265 \times 5280}{32.08} = 43998.86$ sec.; and Jupiter's, $\frac{11.08^2}{302.98} \times 43998.86 = 17826$ sec.; representing a Terrestrial day of 24 h. 26 m. 37.72 sec., and a Jovian day of 9 h. 54 m. 12 sec. Earth's rotation-velocity, therefore, appears to have been accelerated about 2 per cent., and Jupiter's retarded about $\frac{1}{3}$ of 1 per cent. (according to Herschel's estimate of 9 h. 56 m.), since the "Beginning," when the Creative Word simultaneously established their nucleal foundations. Similar relations would hold if the Jovian and Telluric rings were formed at the same time, and the terrestrial nucleus did not appear till the inner ring had been slightly condensed.

If we assume Earth's present limiting velocity (VII) as the indicator of aggregating force, we have $n\ \pi\ \sqrt{fr} = 43200 \times 32.08$ ft. $= 262.47$ m. per sec. The solar modulus of light,† at the principal centre of gravity of our system (*c. g.* ⊙ and ♃), is 505400 solar radii. Therefore the nucleal-formative $v = \sqrt{505400} \times$ the atmospheric v, and when the nucleal v was the v of light ($.4316r$), the atmospheric $v = .0006071r = 262.47$ m. This would make Sun's distance $(214.86r) = 92,891,300$ m.

Since the velocity of primitive nucleal rotation varied within the nucleus as r, communicating a similarly varying *vis viva* to the shrinking nucleus, the above indicator gives, as the theoretical time of solar rotation, $365.256 \div \sqrt{214.56} = 24.912$dy., which implies an equatorial velocity of $.0000029192r$ per sec. Astronomical observations, and Props. VI, VII, and X, therefore,

*Hence, perhaps, the similar density of Sun and Jupiter.

†$v = \sqrt{2fr}$; ∴ r, or *modulus*, $= v^2 \div 2f$. This involves Alexander's postulate of æthereal inertia.

furnish the following approximations to the rotation velocity, the unit being one ten-billionth of Sun's radius:

Spörer, maximum.	Nebular action.	Light action.	Schwabe.	Spörer, minim.
29533	29192	28622	28511	27863

According to the same indicator, the present height of possible solar atmosphere, or the radius of equal centripetal and centrifugal solar force should be $(214.86)^{\frac{3}{5}} r = 35.873\, r$; the time of planetary revolution at Sun, $1yr \div (214.86)^{\frac{3}{2}} = 10020.242$ sec.; the present limit to the velocity of constant pressure, $2\pi r \div 10020.242 = .000627049\, r$ per s; the present solar modulus of light, $(.4316 \div .000627049)^2 r = 473755.65\, r$; the present modulus atmosphere, $35.873 \times 473755.65 = 16995141 r$.

If we locate the Stellar-solar paraboloid by a vertex at $\frac{1}{\pi}$ solar radius, (the primitive locus of complete association), and an abscissa ($x_{35.873} = 35.873 \times$ modulus) at the present surface of modulus-atmosphere, the general equation, $x_n = \xi\, \eta \pm n\, \zeta\, n^2$, furnishes 9 abscissas between Sun and Mercury, and 9 between Neptune and a Centauri, the central 9 representing points of dissociating planetary velocity (VIII), as will be seen by the following table of secular elements:

n	Log.	x_n	Perihelion.	Mean.	Aphelion.
9.873	$\frac{3}{4}$☿	1.6774	1.6806	1.7950	1.8855
10.873	$\frac{1}{2}$♀	1.9099	1.8586	1.8905	1.9200
11.873	$\frac{3}{5}$⊕	2.1541	2.1256	2.1561	2.1845
12.873	$\frac{3}{4}$♂	2.4102	2.3248	2.3901	2.4468
13.873	$\frac{4}{5}$Ast.	2.6779			
14.873	$\frac{5}{6}$♃	2.9575	2.9420	2.9692	2.9949
15.873	$\frac{6}{7}$♄	3.2488	3.2064	3.2447	3.2799
16.873	$\frac{7}{8}$♅	3.5519	3.5217	3.5571	3.5897
17.873	$\frac{8}{7}$♆	3.8668	3.8614	3.8678	3.8740
36.873	a Cen.	7.6622	7.6571		7.6860

The tabular logarithms for a Centauri (7.6571 and 7.6860) represent, respectively, the least and greatest estimates of its distance that have been made. The values of the secular planetary perihelia and aphelia are taken from Stockwell's "Memoir on the Secular Variations of the Elements of the Orbits of the Eight Principal Planets" (Smithsonian Contributions, 232, pp. 37, 38).

It is of course impossible, under the present limitations of our knowledge, to determine to what slight extent the foregoing calculations should be modified, by allowances for orbital eccentricity and other considerations. It seems likely, however, that the parabolic abscissas (X) are the fittest representatives of primitive nebular condensation and retardation, while the forces of constant pressure within the primitive nucleus furnish the closest approximation to the ultimate light-activity. If this opinion should

be confirmed by the discussions of the late transit of Venus, the accuracy of my chemical estimate of Sun's mass and distance* will be likewise confirmed.

The generalization of Faraday, as corroborated by the measurements of Weber, Kohlrausch, and Clerk Maxwell, is thus extended to include gravitation, as well as electrostatic and electrodynamic action, in the same category of central force with light (VI), by means of an identical limiting *vis viva*. The simple mathematical correlations make the generalization still broader, so as to embrace heat (IV), chemism, cosmical and molecular aggregation, dissociation, rotation and revolution (V–X), and all central forces (I–X).

The Flow of Water Through an Opening in a Pierced Plate.

By Robert Briggs.

(*Read before the American Philosophical Society, November 3d*, 1876.)

The consideration of the subject of the *vena contracta*, or section of a vein of water emerging from an orifice under certain conditions, is made a portion of the proceedings of the Philosophical Society of Glasgow, and appears in their volume X, page 145 et seq. Four papers are published, the first of which is an extract from a letter of William Froude, Esq., C. E., F. R. S., to Sir William Thomson, dated Cheston Cross, Torquay, 20th December, 1875. Mr. Froude is quoted† * * * * * "One result I have tried came out well:—The discharge through an introverted cylinder [tube] with keen edge. Here, by theory, the section of the jet ought to be exactly half of the aperture. For the conservation of stream line energy obliges the velocity to be that due to the head, while the conservation of momentum requires that the pressure on the aperture (which is here the sole operative pressure setting in the ultimate direction of the velocity generated) is only sufficient to create as much momentum, say, per second as will be resident in the length delivered per second, of a column of discharge, of half the sectional area of the aperture, if its velocity is that due to the head.

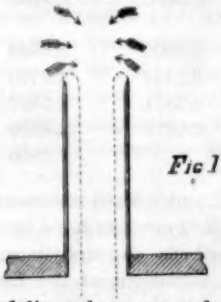

Fig 1

"The cylinder was quite smooth outside and the edge quite keen. The area ratio came out 0.503, 0.502, &c., instead of 0.500, and the little excess was obliterated, if the head was counted, to about one-fourth the diameter below the edge; as indeed it ought to be (I won't swear to the exact figure

*Proc. S. P. A., xii, xiii, *loc. cit.*

†The entire article is quoted, the hiatus indicated by asterisks exist in the published Proceedings of the Glasgow Society.

one-fourth), because till the motion of the particles is purely parallel to the axis, there must be some accelleration to be effected in the direction of the axis, and this demands the employment of some vertical pressure. * *

"In the *vena contracta* experiment with the thin plates and open air between the plates, the fluid was welcome, if it pleased, to start tangentially to the plane of the aperture as here indicated, and as it appears to do if closely studied. So also with the introverted cylinder; although it was not possible to see what happened I have no doubt that the motion of the particles *next* the edge was vertical upwards, the curvature being only such as the pressure in the contiguous stream would satisfy. If the experiment was not adroitly initiated, the water seized the inner surfaces of the cylinder and run out in an eddied condition, filling the discharge pipe. When, however, it was properly started, the contracted column below issued with beautiful smoothness and symmetry."

Fig 2

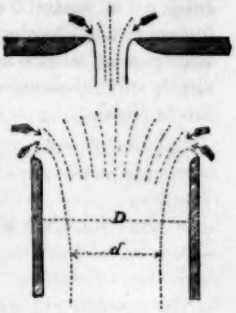

Fig 3

The second paper on the subject is an extract from a letter of Sir Isaac Newton to Professor Cotes, March 24th, 1710–11; from the "*Correspondence of Sir Isaac Newton and Professor Cotes, including Letters from other eminent men,*" published in 1850, by Mr. J. Eddlestone, Fellow of Trinity College, Cambridge, from the originals in the Library of Trinity College. This letter possesses much value as showing Newton's experiment and discussions of the form of the *vena contracta*, and will be found interesting to examine in the proceedings of the Glasgow Society by those who have not ready access to the primary publication. Newton found the *vena contracta* from an aperture in the *side* of a vessel of thin sheet tin plate, five-eighths of an inch in diameter, to have, at the distance of one-half an inch from the hole, a diameter of 21-40ths of an inch. Which was a reduction of diameter of 21-25ths, and of areas of cross section of 0.7058.

A foot note to this letter of Newton by Mr. Eddlestone says, that '*Sectio vena contracta*' was a term used by Jurin, Philosoph. Trans., Sept.—Octo. 1722, p. 185; and that Dan. Bernouilli uses the same term, Hydrodynam., p. 65. Jurin also uses '*vena contracta*'; in all these cases the words denote the reduced section only, while subsequent usage generally applies them to the stream itself as a body, between the orifice and the point of reduced section.

The third paper is a discussion of the *vena contracta* by Professor James Thomson, LL.D., C. E., University of Glasgow, and is a mathematical discussion with six illustrations, intended to demonstrate under certain conditions, as for instance the supposed absence of fluid friction or viscosity, and a supposed great magnitude of vessel and depth of water compared with the dimensions of the orifice, that the jet of water issuing from an

orifice in a thin plate, from a conical adjutage either protruding or re-entrant, has a section, where the stream flows out in sensibly parallel lines, of *more* than half the area of the orifice, and that this condition only ceases for a re-entrant nozzle, in the form of a parallel tube as treated of in Mr. Froude's paper. The conclusions of Professer Thomson do not seem to the writer as warranted by the conditions to which he limits his proposition. The value of the assumed force which he denotes by P is by no means satisfactorily exhibited. As the purpose of this paper is to discuss other points, further notice of Professor Thomson's article may be omitted, only it will be assumed that the reader of this refers to the Glasgow Society's proceedings to see for himself what is set forth by the Professor.

The fourth paper is an abstract of remarks by R. D. Napier, Esq., who gave some consideration of this subject, which was published in 1866, in a pamphlet "*On the Velocity of Steam, &c.,*" in which he made the general assertion, with some qualifications, that the area of the true theoretical *vena contracta* is half that of the orifice. He says, "I have proved in the pamphlet referred to, that the pressure in the plane of the orifice is nearly half the pressure due to the head, and that from thence to the *vena contracta* [the words are here used in the sense of the section of least area] it gradually diminishes to zero. This diminishing pressure causes increasing velocity, and is thus the direct cause of the *vena contracta*. * * * "About three-eighths of the ultimate velocity and five-eighths of the *vis viva* is imparted to the water outside of the plane of the orifice, and it is absurd to attribute these effects either to what I may call the converging momentum being transferred from one side of the orifice to the other, or to the converging particles preventing the free egress of the stream through the orifice, which are the only views hitherto offered to explain the cause of the *vena contracta*."

This question of the *vena contracta* is a very pretty one in physics, and deserves a more complete and general discussion than it receives in the pages of the Glasgow Society. It should be recognized however, that it does not admit of the simplicity of investigation, either mathematically or experimentally, which the papers of Mr. Froude and Professor Thomson assume. It is impossible to divest the consideration from the fluid friction against the contiguous sides, surfaces, or the edges of the aperture, nor from the fluid friction of the liquid within itself which constitutes *viscosity;* nor yet further, from the frictional resistance to discharge into another medium (the atmosphere in this case); while the absolute strength of water is brought into action in the emerging column to the extent of pressure of the atmosphere. Values for these various elements can be accepted, and the mathematical investigation proceeding from them, would enable a thorough solution of the problem, in place of the extremely partial one essayed in the proceedings of the Glasgow Philo. Soc. Even the effect of dimension of vessel or volume of water with relation to the aperture might be made a part of the investigation and appear in the result.

In such an attempt to find a general solution of the theorem it would at

once become evident, that there are two normal forms for the *vena contracta*, viz.: That, when the stream emerges *downwards* from an opening through horizontal edges, and that, where it emerges *upwards* through an opening of the same character. The first of these gives a pencil, whose shape for its longitudinal section at its upper end, or origin, will be controlled by the nature of the aperture, and by the effect of the initial directions of the particles of the effluent liquid (the theoretical *vena contracta, under pressure, but devoid of gravity*); modified by the effect of gravity, which would give to any descending pencil of a fluid, the motion of whose particles shall be established in approximately parallel lines, a hyperloid contour. The second of these will give a sheaf, whose shape at the point of efflux, will be determined by the same laws; while it would now be modified at this point, by the *load* of the emerging fountain, and at the same time the form of the stream above (in this case attaining on some plane an absolutely contracted section), would be that of a hyperboloid sheaf, with both *external* and *internal* lines of definition. If it be supposed in this second instance that the plane of efflux (of the orifice) is slightly deviated from the horizontal, so that the emerging stream is made to take a line out of the perpendicular one, the sheaf form would be disturbed; and at some quite small angle of deviation, a trajectory curve would take its place.

The general course of the stream would then have a modified parabolic curvature—a trajectory curve, which has been frequently discussed—but the exact contour of the pencil is still an open question. It is certain than when passing the point of greatest elevation, it would have, from its retarded motion, its greatest cross-section, and that this cross-section would be a flat oval of peculiar form; and it is probable that beyond this section, on the descending stream, it would become nodal, for the same reasons that a stream emerging from any orifice except a circular one becomes nodal.* In short the complete solution of the problem not only admits and assumes values for all the physical conditions, but it will embrace all directions of efflux from 0° to 180°, where 0° may be taken as the perpendicular direction, either upwards or downwards.

It is possible, for the purpose of illustration, to give some consideration of the *vena contracta* upon hypotheses similar to those of Professor Thomson, and if other conditions are assumed at the same time, an *appreciation* of the phenomenon can be had. In truth the view it is proposed to offer may go further than a mere appreciation, and may be made the basis for support of the other fundamental controlling conditions, and indicate the true line of procedure for mathematical investigation. Let us suppose, with Professor Thomson, that the effect of fluid friction, or viscosity, is neglected; that the magnitude of the vessel and the depth of liquid, is so large in relation to the dimensions of the orifice, that no appreciable velocity is imparted to the mass of liquid by the discharge; that the jet is one issuing downwards (so as to have the cross-section under absolutely uni-

* See article by Weisbach, "Ausfluss," in the "Allgemeine Maschinen Encyclopädie."

form pressure); that the orifice is a circular hole in a thin plate—the flat bottom plate of the vessel—and that the effect of gravity on the stream after emergence be neglected, as well as the atmospheric resistance and the acceleration due to the column of discharge, in the production of a vacuum upon the sectional area; and the following sketch (Fig. 4) gives a general ideal view of the *vena contracta* under these suppositions.

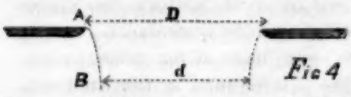

Fig 4

Weisbach* has observed that the actual diameter — d of the vein of emergence from a thin plate, is about 0.8 D; at the point B, which will be found from one-fourth to one-half the diameter (— D) from the plate; and this is accompanied with an efflux, as measured by the quantity of water discharged, of — 0.97v, where v — the velocity of flow — $\sqrt{2gh}$. Now it is an obvious conclusion that at any point on the surface of the *vena contracta* between A, the edges of the plate, and B, the point of minimum section, a particle of water must be in such equilibrium of pressure as to establish its direction of flow, or in other words its curved path; when it becomes apparent that some momentum must have been imparted to such a particle, to induce it to follow in its line of trajectory, instead of following the direction due to gravity, or to the application of the pressure normal to the head, or column of water above it. An attachment to the orifice can be constructed which will exhibit this phenomenon, or rather provide for its occurrence as a matter of necessity, as follows: Let there be an opening in a thin plate as before (Fig. 5), and let this opening be *guarded* or protected by a disc (Z) of the same diameter, — D, let this disc be placed so that its edges (C C) shall be one-eighth the diameter — $\frac{1}{8}$ D (C A) removed from the hole. On these suppositions, if the diameter of the section of least area, — d, be taken at 0.707 D, then the area of the peripheral opening (at C A) will be equal to the area on the plane of (B). The line of effluent stream (A B) may be imagined to be a quadrant of a circle, which will then have of course, a radius, — 0.147 D. Now let the face of the disc Z be made a conoid, so that the areas of the surfaces of the conical frustra a b c d e shall be equal, or in other words, so that all the sections normal to the curve A B shall be equal.

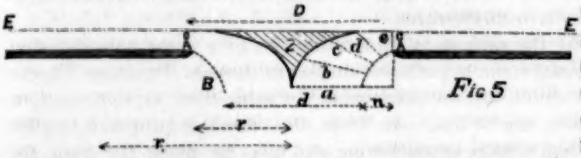

Fig 5

[The co-ordinates for this curve of the face of the conoid Z, in terms of x and y, where x is supposed to have its origin at point of the prolongation of the line CA on the line B; are given by the equation:

$$y = \frac{\sqrt{[r^2 + n^2 \pm \sqrt{(r^2 + n^2)^2 - 4n^2x(2r - x)}] - 4(r-x)^2(r+x)^2}}{2(2r - x)}$$

*Weisbach's Mechanics.

In this equation r = the radius of the opening commencing at the origin of x, and n = the radius of the quadrant or corner commencing at the same point.

The assumption of the quadrant of a circle for the path of the effluent particle from A to B, has been made in order to give a simple equation for, and ready comprehension of, the nature of the sections of the stream normal to its face on A B where, by equalities of areas, uniform velocities would subsist; but the real curvature (A B) is obviously parabolic, and the plane of B is infinitely distant from (below) the plane of A. Observation has shown, that at about one-fourth D below the plane of A the least section of *vena contracta* is apparently reached, and that below this plane of section, the pencil of descending current has its sides with only so much divergence from parallelism, as is due, almost entirely, to the acceleration of the falling stream. An elliptical quadrant which shall approximate to the true parabolic curve can be readily substituted by construction (or calculation) for the quadrant of a circle, in the equation above quoted, and the new values for y, will give loci for the curve of the face of the conoid Z to correspond to the substitution. The value of the radius of the minor axis on the line B as determined by observation, may be taken as that of (n) in the equation. By this method a very close approximation towards the true form may be attained.]

It will then result that the efflux from the peripheral opening C A inwards, having any given velocity, will, in every part of the current, until the least section of the *vena contracta* on the plane B is reached have a uniform and constant rate of speed; neither acceleration, nor transformation of head into velocity, will have occurred in the change of direction. If the consideration of the fluid friction, etc., be not taken into the question, and the velocity of efflux at C A is that due to the head, that at B is established and maintained; whence any liquid particle on the surface A B must be in equilibrium of pressure, both from head or momentum in direction of its flow, *in which direction the entire head is transformed into velocity.* The plate, or plane surface of D, may be imagined to extend indefinitely in the directions, E E, in which case the velocity of flow of liquid, interposed between the plate E and the bottom A, will decrease as the radial distances from the edge of the aperture; in inverse ratios of the radius r to any new radii $r_{/}$ $r_{//}$ $r_{///}$: while the height, of liquid column corresponding to the several velocities, = V at r, $V_{/}$, at $r_{/}$, will vary as $\left(\frac{r}{r}\right)^2 : \left(\frac{r}{r_{/}}\right)^2 : \left(\frac{r}{r_{//}}\right)^2$ &c. The pressure or total height is supposed to have been completely transformed into velocity, = V, at the peripheral opening C A, and the stream or sheet of fluid would exert no transverse pressure at C A, either upwards or downwards; while the transverse fluid pressure on the supposed plate or the bottom of the vessel would vary as $\left(\frac{r}{r}\right)^2$ (at C A) to $\left[\left(\frac{r}{r}\right)^2 - \left(\frac{r}{r_n}\right)^2\right]$; r_n being any assumed radial distance from the centre of the opening. Thus if the radius r be taken as

one-half inch, and that of r_n as five inches (or ten times r), the velocity of flow towards the aperture at r_{10} would be only one tenth of that at r; the head required to produce the velocity at r_{10} would only be one-one-hundredth of that corresponding to the velocity at r; and the pressure of the head remaining on the plate or bottom at r_{10}, would be ninety-nine-one-hundredths of the total head.

These two pressures on the plate and the bottom would be equal and opposite pressures, and if the plate were removed, the unbalanced pressure on the bottom would represent the force P, to which Professor Thomson gives an undefined value. Its total, is of course the sum of the head upon the area of half the opening, and continuing the supposition of removal of the plate, it is encountered and balanced by the *momentum of the descending mass*, so that the bottom would now be in equilibrium of pressure, and the force P, as an unbalanced one, would disappear.

Returning to the examination of the proposition as shown in Fig. 5: the static resistance of the under surface of the conoid Z in a vertical direction against the flow of water in its radial movement towards the centre of the orifice, and while following the path of the under surface of the conoid, is represented in total by the divergence at right angles of the entire effluent stream; = to ½ D of superfice, under the head which has produced the efflux. The reaction of the flow of liquid downwards is also equal to another statical resistance of the same value, and in the same direction; and as the total pressure on the conoid Z from above, is its entire upper surface, under the head of liquid above it; the one pressure above balances the two pressures below, and the conoid itself is in equilibrium.

If it is now assumed that there exists no frictional adhesion of the liquid to the surfaces of the supposed plate, and of the bottom of the vessel, and the vessel is of indefinite extent, so that the velocity of entry at E E is reduced to an inappreciable rate of flow, then the condition of the formation of a perfect *vena contracta* will have been exhibited. The removal of the guide plate E E, and the removal of the bottom of the vessel, and substitution of a re-entrant tube, would replace the supposed frictionless surfaces by liquid mass, which if it is still continued to be supposed devoid of *viscosity*, would enter the peripheral surface C A with the same force, and in the same direction, and would still preserve the same perfect *vena contracta*. The removal of the conoid Z would provide a fluid conoid of the same shape, *or a distribution of internal strains* productive of the same resistance, and (still assuming the perfect liquid) the same perfect *vena contracta* would follow. If however there is admitted to exist a certain adhesion to the bottom of the vessel, or to the surface or edges A A so that the velocity of a particle on A B is less than that fully due to the head; the surface (d) would then become larger than ½ D, the dimension C A would be properly increased to give the corresponding area of efflux, and the conoid Z would also have such a contour as would permit the uniformity of flow of each and every particle of the liquid at unchanged velocity, in any section of the *vena contracta* transverse to the direction of the flow. This increase

of dimension of the cross section d, and the effect of the descending pencil in accelerating the flow through it, can be taken as sufficient to account for Weisbach's observed value of $= 0.8D$, and position of least section at $= \frac{1}{4} D$, as has been before quoted.

It must not be taken for granted that the writer is arguing that the conoid Z actually exists in the water, but it is here assumed for the purpose of showing that all the phenomena of the *vena contracta* are consistent with the supposition. Mr. Froude's "*tangential*" direction for the fluid in Fig. 2, which he says appears if closely studied, is a portion of the proposition, and this discussion exhibits "the imparting of velocity and *vis viva* outside of the plane of the orifice," as alluded to by Mr. Napier

There is one other point worthy of notice in this radial flow of currents towards an orifice, and the radial direction at the edges of the opening. With or without the assumed central, neutral conoid, this flow is in exceedingly unstable equilibrium, especially when in contact with a bottom plate, (the friction or adhesion to which retards the flow), the radial direction may be diverted to a small extent, so that the particle of water where it curves at the point A, or at any other point on the line C A may possess absolute momentum out of the line towards the central axis of the pencil.

The radius of the opening calls for a very slight deviation of entering horizontal current, when its dimension is compared to the area from which this current is derived ; and there is really but the slightest cause for the currents to direct themselves to the exact centre of the orifice. In point of fact the permanency of the *vena contracta* of downward discharge is derived in great degree from the pressure of the atmosphere, which is brought into action, by the descending pencil below it. The effect of a tangential afflux at the peripheral circle C A is to give a rotation to the pencil, which at once accelerates, to some limit of discharge, and obliterates the *vena contracta*. The motion of the particles will yet remain limited *in any direction* by the head, but as the stream emerges with a rotary motion, the path of any particle becomes a spiral one, and the whole pencil advances, or is discharged, at a slower rate than is due to the particle velocity. In the case of the re-entrant tube, where the pencil is divested from the effect of gravity, by exhaustion of the air by the effluent stream passing from the tube, it is very difficult to get a *vena contracta*, as Mr. Froude testifies. This action of the tangential afflux is not confined to the emerging stream, but shows itself in the vessel as well, where a whirl is established which involves the entire mass of water enclosed. In the case where the bottom of the vessel has a funnel shape, this whirl sets up with great vehemence, and the centrifugal force of the established current may be sufficient, under favorable circumstances of form, head and dimension of vessel, to displace the entire central portion of the liquid, and the pencil of emergence will become a tube, whose core will be filled by an induced current of air. These phenomena of efflux are only noticed to embrace in my remarks some of the influences which effect the *vena contracta* where the conditions of formation are varied by adjutages, and to make it evi-

dent that neither the study of phenomenal nor the mathematical considerations involved, have been exhausted in the papers of the Glasgow Philosophical Society, while the present article does not pretend to do more than to indicate the direction in which enquiry should be pursued.

Remarks upon the Tónkawa Language.

By Alb. S. Gatschet.

(*Read before the American Philosophical Society, Nov.* 17, 1876.)

A small body of Texas Indians, the wretched remains of a once powerful tribe, bears the name of *Tónkawas* or *Tónkaways*, and is called *Tónkahuas* by Spanish writers. Through the unfortunate homophony of their name, they were frequently confounded with the Central Texan or coast tribe of the Towakonays, who certainly were congeners of the Wichitas and Wacoes, and led a nomadic life in close community with the Karankáhuas, Arrenámus and Caris. A bay in the middle part of the Texan Gulf Coast is called Carancáhua Bay up to this day. At the time when Spanish missionaries, along with a number of their Aztec helpmates, had colonized the South of Texas, and disseminated the germs of the Roman Catholic faith among the untutored tribes of aborigines, whom they induced to join in agricultural pursuits in the vicinity of their missions, the Indians were treated with humanity. Then Mexico and all Spanish America freed itself from the domination of the distant mother country; Texas declared itself independent from Mexico, and when after another lapse of time the Texan settlers proclaimed their adhesion to the American Union, a war of extermination commenced against the helpless Indians, which up to our days continues without abatement on the northern border against the roving bands of the Lipans, Comanches and Kiowas.

The Tonkawa tribe, however, whose first mention in American annals occurs at the commencement of this century, seems to have suffered more from internecine wars and feuds with the Comanches, than from white settlers. In 1847 official documents put down the number of their warriors at 155, a decrease of about two-thirds since 1820. The remnants of the tribe, about 35 warriors with their families, are with a number of Lipan-Apaches at present gathered on a reservation in Shackleford County, Northern Texas, seven miles from Fort Griffin. They raise stock, hunt the buffalo, and serve as scouts on the expeditions of the United States troops stationed at Fort Griffin. They are exceedingly filthy in dress and habits, paint their faces in a grotesque manner, and live in canvas tents. Their national legend represents them to be the offspring of the *wolf;* hence this animal is worshipped in their *wolf-dance*, of which Schoolcraft has given a description (in Vol. V).

Two Bavarian gentlemen have lately visited and studied this obscure and half-forgotten tribe, and have favored me with their notations on the na-

tional idiom. One of them, the chemist Oscar Loew, visited in August 1872 that section by order of the "Texas Coal and Copper Mining Association" for metallurgical and mining purposes, and in subsequent years became a very efficient member of Lieut. Geo. M. Wheeler's Surveying Expeditions west of the 100. Meridian. His field-notes on Texas and the Tonkawas have been published in "Petermann's Mittheilungen," Gotha, 1873 (December). The linguistic materials collected by him and Mr. Fr. von Rupprecht were published in full by me in my recent book:

"*Zwölf Sprachen aus dem Südwesten Nordamerikas, Weimar* 1876;" and this article here merely contains the results of a closer investigation, hitherto unpublished, of the Tonkawa words and sentences transmitted to me.

Tonkawa differs absolutely in its radicals from all surrounding American tongues, and the few terms coinciding seem to have been *borrowed* from neighboring idioms. Most syllables *begin and terminate* with consonants, but consonants never preponderate in number so as to obscure the pronunciation of the vocalic elements. The consonants composing T. words are as follows:

Explosives: k, g; t, d; p, b; x; tch.
Spirants: s, sh, h, v, y (in English: *yoke*).
Liquids: n, m, l, r.
f does not occur; d and r are scarce, and g very unfrequent.

Among the vowels i, e, a, o, u (all sounds were given here the *Italian* pronunciation), *a* alone is softened into the "Umlaut" ä (ekkvan and ekkvän *dog*) and forms the diphthongs ai and au. No other diphthongs exist but eu, ei, oi; and those formed with y (ya, ye, yo, yu), if we choose to call them diphthongs. As in most of the Northern idioms of America, vowels frequently form a hiatus: e-e-ion *week*, esamó-i *broom-weed*. Combinations of three consonants frequently occur, but they never sound unharmoniously to our ear, and in fact the Tonkawas seem to be endowed with a remarkable sense for linguistic euphony. They lack the softer palatal dsh, and all the aspirates but χ (or kh): the hard guttural occurring in Welsh, in German ("trachten") and in Spanish (j in *mujer, dejar*); -s at the end of words generally becomes -sh or -tch, and it alternates throughout with sh. A final -n is exceedingly frequent. The mutes often alternate among each other, b with p, g with h, k and χ (and t with tch).

Redoubling the monosyllabic root is a means of grammatical synthesis extensively used for *various* purposes by all languages known; the T., however, seems to employ it almost only for onomatopoetic purposes, as in: tchatchaya *to laugh*, koχoχua *to breathe, perspire*, tchutchuχ *to be scared*. The nature of the material available does not as yet allow to establish general grammatical laws for the T., but permits a glimpse at its method of compounding words, and gives a few indications of structural import. The system of the object and subject pronouns seems to be rather intricate.

The negative particle *not* consists of two parts, *ka* and *pa*, which are frequently placed one aside of the other, as in Apache, and in Tehua (New-

Mexico). But more frequently only one part of it appears as k', ka, g'; b', ba, p', pe—as in: tcheno *to be,* tchapeno *not to be;* ne-enoχ *to know* (?), nek-enoχ *to ignore,* gin'χenu *I do not know* (g is here the negative particle); shai *ka* tu lel *I have no time;* shaya yétsoχanak on *be: I was not in the house.* Where it can be done, the negative particle is incorporated into the stem of the verb as *ba* or *bó:* hé-el yaχa *he eats,* hé-el yaχabó *he does not eat,* χaχaha *I was* or *went,* χaχabaha *I was not* or *did not go. No!* as a negative answer to an inquiry is *aga,* (*a-ka*)!

Kapa, the two particles combined, or *kapai, kapa-i,* evidently has the force of an adjective: "none, nothing": shai aχ kapa yeshik *I have* NO *water;* shai aχuenχa kapa yévuesh *I have no horse.* It is also pronounced *kopei, kopeia,* and in this form occurs as a privative particle in compounds: shenχōn *dress, coat:* sankuon-kopei *naked,* kopeia-veika *poor, indigent* (the root of veika lies in yé-vuesh *to be possessed of*).

The first syllable of the word (ka-, ko-) probably occurs also in a protracted form in ka-a *sick.*

PREFIXES.

A number of *prefixes* can easily be pointed out in T. verbs and nouns, but to find out the real power and original meaning of these prefixed syllables is a difficult task. *He-* is a frequent prefix in nouns and verbs, and is found also in interrogative pronouns and particles as well as in the demonstrative pronoun of the third person singular; hé-el, helatla, *he, himself.*

he-yatchon *eyeglass,* cf. atche *to see.*

he-lepuen *tree, forest.*

he-ntaitchon *tooth.*

he-nshon *blood* cf. ya-tson *heart.*

ha-lonkaiχaχ *knife,* cf. ya-lona *to kill.*

ha-wei, ha-vei *large, big, high, tall.*

he-ktau-e *to sing, chant.*

ha-iχo *to ride on horseback.*

The prefix *ne-* occurs quite often and is used in forming verbs from nouns and nouns from nouns or verbs, as can be inferred from the following examples:

ne-baχka *to smoke,* from baχka, the English word *tobacco.*

ne-shuana *to shoot,* and ne-svon- in the compound nesvon-pillel *round of ammunition.*

ne-vauva *to expire, die.*

ne-k-enoχ *to ignore* (lit. "not-well [know]").

ne-muetan *eye* (root probably in metan *to flash up*).

ni-muetchχon *nose,* derived from the preceding.

ni-kamon *bone.*

ni-steχon *ice,* from teχon *rock, stone.*

ne-shgashan-oyuk *towel.*

The most frequent of all the T. prefixes is undoubtedly *ya-, ye-, yo-,* found in verbs as well as in nouns. In active verbs it seems to fulfill the functions of an object-particle incorporated into the verb, as we see it occur-

ring in many Mexican, Southern and Northern languages; in Aztec f.i. the particles *te-, tla-, tetla-,* are used for this purpose. The nature of this particle is elucidated by the following grammatical juxtapositions:

kala *mouth:* ya-χa *to eat.*

shaya *tchen* vantch *I see thee:* naya ki *ye-tchu thou seest me.*

veika *possessed-of, having* (in: kopeia-veika *indigent*): shai yé-vuesh *I possess* (aχuenχa *a horse*): auvash ye-yaχanosh *I eat buffalo-meat* (here the particle occurs twice).

In these sentences the particle *ye-*, connected throughout with transitive verbs, has a reference to the direct object, which either precedes or follows the verb. It is found to occur also in the following transitive verbs: ya-lona *to kill,* yo-χoya *to hunt,* perhaps also in eisatuk *to cut, sever,* if this term is misspelt for ye-satuk.

Some of the following substantive nouns built up with this particle can be distinctly traced to their respective radicals:

yé-tsoχan *house,* originally *tent,* from tsoχ *cloth.*

ye-tsoχe i-tsan *button,* from tsoχ *cloth.*

e-shauké-huen *shirt* (probably instead of ye-tsoké-huen, from tsoχ *cloth*).

ya-χau *spur,* from χaχa *to go* (or to make go?).

ye-koχon *boot,* from kaχa, χaχa *to go.*

ye-keván *entrails, guts,* from kevano *wet.*

ya-teχon *stone, rock,* cf. helepuen-teχek *"mountain-forest."*

ye-ntan *wind.*

yo-tchan *nail* (on fingers and toes).

ya-tson *heart.*

ye-la *chair, seat.*

e-baχu-eta *woman* (instead of ye-baχu-eta?).

ya-tch-χenon *bread,* from yá-χa *to eat.*

The word for *stone, rock* seems to have two forms: *teχon,* and *ya-teχon,* and the circumstance, that this prefix *ya-,ye-* is generally found in substantives along with the affix *-an, -on, -en,* etc., proves that there exists some connection between the two. Evidently they are the two principal elements used in building up substantives from the monosyllabic roots.

There are many reasons for assuming that *s-, sh-* is a Tonkawa prefix, though it cannot yet be distinctly proved to be such. It occurs in the following pronouns, nouns and verbs:

shaya, shai *I, myself.*

hetet-shá *whereto?*

hetet-sho-olok *what thing?*

shapon *to hide, conceal.*

shoyana to *swim,* cf. esvalan *fish,* aye *to move,* or *live in water.*

soskuono *to hear* cf. χaion (in :-enatch-χaion *ear*).

si, se- is also prefixed to the numerals 4, 6, 7, 8, 9, 10.

A few terms of Loew's vocabulary begin with the syllable *ok-*, which I presume to be rather a generic term than a prefix. Perhaps it means "animal" or "quadruped," for it occurs in okau *skin, fur-skin,* okemeillo

hog, swine, okmek *lion,* and probably stands also in the initial syllable of okopák-χōn *hat* (originally made of skins or fur), in : aχuenχa *horse,* and *ukuen dog,* which is spelt ekkvan by Mr. von Rupprecht. We have here another instance of the curious fact that the horse and the dog are called by Indians with the same root or word-stem and we would possess many more of these instances, if the horse was not so frequently called by the imported Spanish term kaway, kaváyo. The following table gives an enumeration of the terms for *horse* and for *dog* from various tongues :

Isleta (New Mexico)	ganidá, *horse*	kuyanidá, *dog.*
Natchez	wvskupser	wvskup (v = a short surd ă.)
Yuma-Tonto (Arizona)	χata	tsata.
Dakota	shunktánka	shúnka.
Payute	pung-gú	pung-gúts.
Sahaptin	kússi	kússikussi.
Wintoon (California)	shuku	kanti-shuku.
Klamath	uátch	uatchága

The last-named term *uátch* simply means "living creature, being," and *uatchága* is its diminutive, from *uá to exist, to live, to stay;* applied to our Tonkawa terms composed with *ok-,* this supports the opinion, that *ok* and its compounds have a similar signification of *creature,* or animated *being.*

The Natchez term for *horse* is the augmentative of wăskup *dog,* and as Dr. D. G. Brinton has shown, *wăs* is "apparently a generic term for a certain class of animals," and occurs as *wĕ* in the language of the Uchees or Yuches, which forms a similar series of compounds.

Okemeillo *hog, swine* is really the "beast feeding on the meadow," for hueu-meil means *prairie* or *meadow.*

AFFIXES.

Of a more diversified character than the formative prefixes are the *formative affixes,* that is the syllables *appended* to roots or word-stems, and intended to form derivatives.

We frequently meet f.i. a terminal syllable -i in nouns, which is appended almost only to vowels and often coalesces with them into a diphthong :

shaχe-i *shadow, shade.*	aχaloi *ant.*
esamo-i *broomweed.*	kapai *nothing.*
také-i *head.*	tei-i *liver.*
tsélai *cloud.*	senanda-χas-i *copperhead snake.*

A second derivational affix *-eta* occurs in the words :

nemuetan *eye.*

beχueta, ebaχueta *woman.*

keta-, kete- *friend, partner* (in : ketepanon *my partner*).

Compare this affix with eta *to come* and with the particle hetetá? *where?*

A third affix in *-k* (-ak, -ek, -ik, -ok) frequently turns up in substantives, adjectives, and other parts of speech :

kalok *beard, mustache,* from kala *mouth.*

tsatsχok *piece, slice* (f.i. of meat).
χak *hair* (on head).
galak *more.*
hitanok *soon, in a short time.*
malek, in : nemuétan malek *eyelid.*
ok-mek *lion.*
oyuk *sack, pocket, bag,* cf. toyo *to put into.*
namek *dry wood.*
makik *yellow* 2) *gold.*
masslok *white;* 2) *cattle.*

This -k affix seems to indicate a spot or place and may be equivalent sometimes with "*on him, on it, on this.*" See the locative case below.

The existence of a fourth affix *-la, -lan, -lo* (o frequently alternates with a, both being probably surd ă), occurring as yet in substantive nouns only, may be inferred from the following words :

anip-'hel-la, enopχa-lo *moskito.*
apinki-llin *fly* of various colors, red, etc.
esva-lan *fish,* enko-ó-la *bird.*
haku-lăno *valley* "where *water* is," cf. aχ *water.*
ka-la *mouth,* from ya-χa *to eat.*
kva-lo *stick,* in ne-χo-o-kvalo *gun, rifle* from kue, kve *wood.*
χa-lan *fever and ague,* from ka-a *sick.*
χa-lo *tumbler, drinking-glass,* from χane *to drink.*
masloχ-é-lan *snow,* from masslok *white.*
naχtchon-se-lon *fire-match,* from naχtchon *fire.*
tcho-ó-lan *excrements.*

-la is found also in the personal pronoun helat-la *he, himself,* but this is most likely the particle *ala,* which occurs in many other pronouns and is here apocopated, as the possessive élatan (*his, hers,* or *its*) demonstrates.

In the numeral series, this particle *ala* is used to form the decades or tens and may be rendered by "*times*":

sikbaχ *ten.*
sikbaχ ala kita *twenty,* (10 times 2).
sikbaχ ala mitish *thirty,* etc.

In spite of the small number of Tonkawa verbs, of which we are cognizant, some formative endings constantly recur, and we are therefore justified to consider them as derivational affixes forming verbs. One of them is *-aua, -ua:*

atsoχaua *to cool down,* from atsoχ *cool.*
hektaue *to sing.*
koχoχua *to breathe,* keshkua *to be fond of.*

Another, the sixth of our series, is *-ana, -ano, -ono* etc., which we discover in the following verbs:

shoyana *to swim.*
metan (instead of metana?) *to flash up* (said of lightning).
ne-shuano *to shoot.*

ke-vano *to be wet; wet, wetted.*
ke-eiχena *to be hungry; hungry, famished.*
χane *to drink* (same root as yaχa *to eat*).
shapon (instead of shapona ?) *to hide, to conceal.*
yalona *to kill.*
soskuono *to hear.*

This affix is evidently identical with the verb *eno, enu, teheno,* which is rendered by *to be, to exist,* but whose primitive signification is that of *going* or *coming* (ena, aina).

Further verbal formatives can be traced in: *-aya, -oya:*
tchatchaya *to laugh,* yoχoya *to hunt,* toyo *to put into.*
in: *-na, -no:*
shokna *to put into,* tchoχno *to sleep.*

This ending probably originated through the syncope of verbs in *-ana, -ona, -ono* etc.

The most important affix and the ninth in our series is found in all the different categories of nouns (to the exclusion of verbs, probably). This is the affix *-n,* and its occurrence in participles of the active form of verbs seems to give the key to its real meaning. We have, f. i.:
tchoχnon *physician,* from tchoχno *to sleep, to lie in bed.*
atsoχauan *north wind,* from atsoχaua *to cool down.*

In the derivatives quoted hereafter this ending evidently has *different* functions to fulfill:
he-yatchon *eye glass,* from atche *to see.*
ayon *foot* (from aye *to move?*).
ye-koχon *boot,* from kaχa *to go.*
ye-tsoχan *house, tent,* from tsoχ *cloth, canvas.*
Kānoshan *Mexican,* from Kānosh *Mexico.*
táχshon *morning,* from tagash *sun.*

But the terminals *-an, -en, -in, -on, -un* appear also in a considerable number of nouns, whose roots, stems or their meaning are yet a mystery to us (*-kin, -χin* forms possessive pronouns), and of which we give here a short aperçu:

Adjectives:	χaton (also: χatana) *green.*	
	taχon *warm, hot.*	
Substantives:	etchnan *day.*	tan *tail.*
	nitχutan *paper.*	helepuen *forest, tree.*
	hepeian *beads.*	bopaχon *fox.*
	ya-tsoχgan *table-fork.*	tróniχon *grass,* etc.
	natun *hill, mountain.*	

Curiously enough, *-en* also stands at the end of the higher cardinal numbers, from fifteen upwards:
koskua *five,* koskua-en *fifteen,* sikbaχ-ala-kita kita-en *twenty-two.*

Tree or *wood* is kve, kue and the *shadow of a tree* is shaχe-i kauvan; hepeian is *beads,* and taχuaz-loman-hepaian is *neck-cloth, neck-kerchief.* From this we may conclude that *-n* in *kauvan* is the sign of an oblique

case, the *possessive*, and that hepaian simply means "on the neck," or "belonging to the neck," or "of the neck;" then hepai, hepei, or hepaia would be the term for *neck*.

Cases. By a similar analytical process we arrive at the discovery of a few other case-suffixes. Putting together the sentences in which the endings *-ak* and *-ok* are found, we get the following:

shaya yetsoχanak enubaha *I am not in the house.*

shaya yetsoχanak on be *I was not in the house.*

hetsho-olok yaχanoka? *What do you eat? What do you feed on?*

χananoke vauva *to die of poison.*

The two first sentences give us a *locative* case in *-ak*, the two latter an *instrumental* case in *-ok*.

The vowel *-u-* occurs at several places, where it seems to be a case-suffix, but is not yet demonstrable as such. If aχuelpa, for instance, which means *source, spring-water*, is composed of aχ *water* and he-lepuen *thicket, wood, tree*, (springs are often found near thickets), the inserted *-u-* can hardly be anything else but a case-suffix or a particle of relation; secondly: etatχono *to speak* is composed of eta *to come* and χon *a man, man* and therefore signifies in fact "*to come to a man.*" From this may be inferred, that *-t-* and *-o-* (*-u-*) are both particles of relation.

The ending *-sh*, which in verbs is used as a substitute for the pronouns shaya *I* and shaibaχ *we*, does not seem to be used as a case-suffix, but is found sometimes incorporated in the midst of words, as in naχtchon-se-lon *fire-match*, ya-tch-χenon *bread* (*ya-* prefix, yaχa *to eat*). As a final sound we find it in words like:

tagash *sun*, from taχon *warm, hot* (cf. Aztec tonatiuh *sun*, from tona *to be hot*).

nashish *terrapin.*	se-ketiesh *eight.*
auvash *buffalo* cf. au *deer.*	mish- in: mishbaχ *one.*
apinshos *common fly, house-fly.*	nosóss *young.*
mitish *three.*	há-ash *many.* (See: prefix *sh-*.)

Having discussed the more important features of T. grammar in my German publication, I shall not at present dwell any longer upon this subject, but pass over to the etymological dissection of some compound words and wind up with some ethnographical remarks of general interest.

In forming compounds of two substantives, the Tonkawa language places the depending *after* the governing substantive. *Man, male* means a-akon, in compounds akon; it occupies the first place in akon-kválo, the man of the staff or stick, viz.: *the chief;* it stands second in such terms, as designate objects for personal use, instruments, etc., f.i. okopák-χōn *hat* (lit. hat of man). Adjectives not used as predicates seem bound to stand behind the substantive or noun they qualify: aχ iχ *bad water*, akon vóχvan *little, young man, boy.*

From *atche to see* I derive the following terms: etchnan *day;* daylight, shining and seeing being ideas closely connected among themselves; tagash-aitchótak *the east*, lit.: "*sun-where-to see,*" the direction in which

we first see the sun; he-yatchon *eye glass.* If na-ashod *moon* is a term formed after the "*aitchótak*" above, equivalent to "rising," "going-up" (na-aitchót?) and to the Klamath word ka-ukó·lĕsh *moon* (lit. "*the ascending one*"), it must also be derived from atche *to see.*

kue, tree, wood, stick, gave origin to the following T. words: akon-kvalo "the man of the stick," *the chieftain;* tsoχnetch-le-kvan *soap,* viz., "*stick* to wash cloth (tsoχ) with;" nitχutan-kve *lead-pencil,* viz., "paper-stick;" neχoo-kvalo *rifle, gun,* viz., "shooting-stick," probably misspelt for nesho-o-kvalo, ne-shuano meaning *to shoot.* Ekvuahen *horn* is probably derived from the same word, as horns frequently bear some resemblance to pieces of wood (instead of e-kvua-en?), and the numeral *six,* si-kualo, recalls the word kvalo, which is reduplicated in *nine,* se-kueskuelo.

teχon rock, stone reappears in ya-teχon *rock,* ni-s-teχon *ice* (water-stone!) and in helepuen-teχek *forest, thicket,* literally: wood of the hill. This refers to the circumstance that in the southwest forests are found on elevations only, while the plains remain bare of any woods.

atch earth, land turns up in etcho-χanásh *prairie-dog,* the well-known burrowing rodent of the west, Spermophilus ludovicianus, forming extensive underground colonies.

tsoχ cloth, canvas is the etymon of many terms mentioned above, and of: ye-tsoχe-i-tsan *button,* tchoχ-tchapol *blanket,* tsauχ-yetsuχan "*canvas-house,*" *tent;* apparently also of: niese-tsoχ-kanov *dry, dried,* meaning perhaps a *cloth* (tsoχ) *dried* by the wind or the fire. Not knowing the original signification of tsoχ, we cannot decide if tchóχno *to sleep, to lie in bed* is derived from it or not.

a-atchoke rich is derived from ha-ash *much, many,* initial *h-* being deciduous in many of the Indian languages.

au deer, auvash *buffalo,* okau *fur-skin,* nauval *robe, animal-skin* are all derived from the same root *au.*

yentan, yandan wind forms yentan-auvei *the south,* lit. south-wind. Auvei, hauei is *strong* and the "*strong-wind*" is the breeze blowing with impetuosity from the coast of the Gulf of Mexico.

keta friend, partner, is identical with the numeral *kita two* and simply means "we two," or "two of us." From kita *two* are formed the numerals si-kuit *four* and se-ketiesh *eight.*

Conclusion.

The confutation of errors, whether they be of importance or not, is always attended with good results, and if we can profit in science and knowledge by such confutation, we should not lose the opportunity. It will not take long to prove with linguistic reasons, that the supposed affinity of the Tonkawas with the Caddoes does not exist.

Words and syllables in Caddo end almost *exclusively in vowels;* words of one syllable are scarce, almost every word has two or more syllables and in dissyllabic words the accent rests on the penultima. Diphthongs occur, but are often recognized with difficulty, owing to the queer method of

transcribing the language; groupings of consonants rarely occur, in T. frequently. *One simple consonant* generally heads the word and syllable; names for colors begin with *a-* or *os-*. The parts of the human frame mostly terminate in *-to, -co, -no, -son;* others begin with *oko-, okun-*, which would not be altogether disparate from the T. akon *man*, provided it has the same signification. It is true that the Caddo: nishe *moon*, aχkóto *cold, winter* bear some external analogy with the T. na-ashod *moon* and atsoχ *cool*, but there is often a wide difference between resemblance and real affinity. I have given elsewhere a collection of T. words resembling to terms of the surrounding idioms, which might be augmented indefinitely. Only one of the compared languages has yielded a few terms resting probably on real identity, and that is *Aztec*. We find T. (ya-) χa *to eat*, ka (-la) *mouth* and Aztec (tla-) ka, ka (-matl); T. hauei, auvei *great, large*, Azt. vei, huei; T. aχ *water* and Azt. atl. If these coincidences, which Tonkawa has in common with many Sonora languages, are increased by others, we may look out for proofs of old connections between the two ethnical bodies; connections through commerce, expeditions, emigrations or immigrations, not as yet through ethnological affinity. Up to this day a kinship of the Tonkawas with any other American nation or tribe has not been shown, and neither Aztecs, nor Shoshones or Caddoes can claim it on linguistic grounds. A faint resemblance could be traced in two Caddo terms only and phonology as well as grammar disagrees in most particulars from that of the Tonkawas.

NOTE.—Remember well, that the χ used here has *nothing to do* with the English *x*, but represents the harsh, guttural aspirate *kh* unknown to the English language.

On the Atmospheres of the Sun and Planets.

BY DAVID TROWBRIDGE, A. M.

Read before the American Philosophical Society, November 3, 1876.

There are two cases to be considered; in the first place we may suppose the body surrounded with an atmosphere, to be so hot as to influence, to a considerable extent, the density of the circumambient fluid; and in the second place we may regard the planet as cold like the earth, and as we suppose, Mercury, Venus, and Mars. I shall suppose the atmospheres composed of gases which are subject to the same laws as terrestrial gases.

1. Let us suppose the solar or planetary body to be a sphere of radius r. Also let z be the hight of any stratum of the atmosphere above the surface of the planet; ρ the density of that stratum; Z the force of gravity at the hight z; g the force of gravity at the surface of the planet; $\triangle$ the density of the atmosphere at the surface of the planet; p the pressure at the hight z; P at the surface; t_0 the temperature above 32° Fah. at the surface, and t at the hight z; λ the coëfficient of expansion; or the fraction expressing

the increase in volume for an increase in temperature of 1° Fah., so that if V_0 be any volume at the temperature of 32°, it will become $V_0 (1 + \lambda t_0) = V_1$ at the temperature t_0 above 32°; and at the temperature t above 32° the volume will be

$$V_0^t (1 + \lambda t) = V_1 \left(\frac{1 + \lambda t}{1 + \lambda t_0}\right) = V \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1).$$

Since the pressure is equal to the weight, we have

$$dp = \rho Z \left(\frac{1 + \lambda t}{1 + \lambda t_0}\right) dV_1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2).$$

This equation applies for the hight z. We have

$$V_1 = \tfrac{4}{3} \pi [(r + z)^3 - r^3], \text{ and } dV_1 = 4 \pi (r + z)^2 dz \ldots\ldots\ldots (3).$$

$$Z = \frac{gr^2}{(r + z)^2} \quad (4), \qquad t = \frac{r^2 t_0}{(r + z)^2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5).$$

Mariotte's Law gives

$$p = \frac{P}{\triangle} \rho, \quad dp = \frac{P}{\triangle} d\rho \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6).$$

If we substitute these values in (2), and make the second member negative, since ρ decreases as z increases, we shall have

$$\frac{1}{\rho} d\rho = -4 \pi g r^2 \frac{\triangle}{P(1 + \lambda t_0)} \left[1 + \frac{r^2 \lambda t_0}{(r + z)^2}\right] dz \ldots\ldots\ldots\ldots (7).$$

The integral of this gives

$$\text{Log. } \rho + C = -4 \pi g r^2 \frac{\triangle}{P(1 + \lambda t_0)} \left[z - \frac{r^2 \lambda t_0}{r + z}\right]$$

When $z = 0$, $\rho = \triangle$, and $C + \log. \triangle = 4 \pi g r^2 . \frac{r \triangle \lambda t_0}{P(1 + \lambda t_0)}$, and

$$\text{Log. } \frac{\rho}{\triangle} = -4 \pi g r^2 . \frac{\triangle}{P(1 + \lambda t_0)} \left[z + \lambda r t_0 - \frac{r^2 \lambda t_0}{v + r}\right], \text{ or}$$

$$\text{Log. } \frac{\rho}{\triangle} = -4 \pi g r^2 . \frac{\triangle z}{P(1 + \lambda t_0)} \left[1 + \frac{r \lambda t_0}{r + z}\right] \ldots\ldots\ldots (8).$$

Now make

$$\frac{4 \pi g r^2 \triangle}{P} = \frac{1}{R} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (9);$$

then we have

$$R \text{ log. } \frac{P}{\triangle} = -\frac{z}{1 + \lambda t_0} \left[1 + \frac{r \lambda t_0}{r + z}\right] \ldots\ldots\ldots\ldots\ldots (10).$$

Let us take the surface of the earth as the unit of surface, the radius of the earth as a linear unit, and the force of gravity at the earth's surface as the unit of gravity.

2. Let D′ be the density of mercury at the temperature of 32°, and D″ its density at t_0 above 32°; then, if λ' be the coëfficient of expansion for a volume of mercury,

$$D' = (1 + \lambda' t_0) D'' \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (11).$$

Let h′ be the hight of a column of mercury on the unit of surface, and at the temperature of 32°, that will just balance a column of atmosphere

on the same surface, h'' the hight of a column of mercury on the unit of surface on a planet, at the temperature t_0 above 32°; then the mass of the first column will be $4\pi h'D'$ very nearly since h' is about 30 inches, and the weight will also be $4\pi h'D'$, and this will be equal to P_0 the pressure on the unit of surface on the earth. Hence

$$P_0 = 4\pi h'D' \quad \ldots\ldots(12).$$

The mass of the second column will be

$$4\pi h''D'' = \frac{4\pi h''D'}{1 + \lambda' t_0} \quad \ldots\ldots(13);$$

and the weight will be $\frac{4\pi h''gD'}{1+\lambda' t_0}$, which is equal to the pressure P on the unit of surface. Hence

$$P = \frac{4\pi h''gD'}{1 + \lambda' t_0} \quad \ldots\ldots(14).$$

So long as the temperature is constant the density is proportional to the pressure; or $P_0 : P :: \triangle_0 : \frac{P\triangle_0}{P_0}$; and under different circumstances of temperature the density is inversely as the volume for the same mass, so that for the temperature t_0 above 32°, the density just found will become $\frac{P\triangle_0}{(1+\lambda t_0)P_0}$, and this must represent the actual density $\triangle$ at the surface of the planet. Hence

$$\triangle = \frac{\triangle_0}{(1 + \lambda t_0)} \cdot \frac{P}{P_0} = \frac{4\pi h''gD'}{4\pi h'D'(1+\lambda' t_0)} \cdot \frac{\triangle_0}{(1+\lambda t_0)} = \frac{\triangle_0 g h''}{h'(1+\lambda' t_0)(1+\lambda t_0)} \quad (15).$$

3. Let m be the mass of any one of the planets, that of the Earth being 1, A the mass of the Earth's atmosphere, and KAm that of the planet's, then

$$A = 4\pi h'D' \quad \ldots\ldots(16);$$

$$\text{and } KAm = \frac{4\pi h''D'r^2}{1 + \lambda' t_0} \quad \ldots\ldots(17);$$

and hence

$$\frac{KAm}{r^2} = KAg = 4\pi Kgh'D' = \frac{4\pi h''D'}{1 + \lambda' t_0}, \text{ or}$$

$$h'' = Kh'g\,(1 + \lambda' t_0) \quad \ldots\ldots(18).$$

This value in (15) gives

$$\frac{\triangle}{\triangle_0} = \frac{Kg^2}{1 + \lambda t_0} = \frac{P}{P_0\,(1 + \lambda t_0)} \quad \ldots\ldots(19).$$

Equation (10) is independent of the extent of surface on which the atmosphere presses, since it gives only the law of the variation of density of the atmosphere in ascending through it. R is therefore a linear measure, and on the Earth it has been found from observations to be 26,126.5 English feet, or 4.948 English miles. To compare this with a similar quantity for any one of the planets, we must make $r = 1$ in Eq. (9), and we shall make

$$4\pi R_0 = \frac{P_0}{\triangle_0} \quad \ldots\ldots(20), \quad 4\pi gR' = \frac{P}{\triangle} \quad \ldots\ldots(21),$$

in which $R_0 = 4.948$ miles. These equations give

$$\frac{gR'}{R_0} = \frac{P}{P_0}\cdot\frac{\triangle_0}{\triangle} = 1 + \lambda t_0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (22).$$

In Eq. (10) we must therefore substitute for R the value $R' = \frac{(1+\lambda t_0)R_0}{g}$, which gives

$$R_0 (1 + \lambda t_0)^2 \log. \frac{\rho}{\triangle} = - gz \left[1 + \frac{r\lambda t_0}{r+z}\right] \ldots\ldots\ldots\ldots\ldots (23).$$

Equation (23) is independent of K, which depends on the mass of the planets' atmosphere, as it should be since we have neglected the attractive influence of the atmosphere. This seems allowable since the mass of the Earth's atmosphere is but a small fraction of the mass of the Earth.

4. Now let $t_0 = 0$ in (23) and the resulting equation will apply to an atmosphere of 32° Fah.

$$R_0 \log. \frac{\rho}{\triangle} = - gz \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (24).$$

To make some application of these formulas we shall take $g = 1$ and $\triangle = 2\rho$, and since N log. $2 = 0.6931472$ we find $z_1 = 3.4297$ miles; and for $\triangle = 4\rho$ we have $z_2 = 6.8594$ miles, and so on, $\triangle = 2^n\rho$ giving $z_n = nz_1$.

Now let us suppose $g = 1$ and $\lambda t_0 = 1$, then, $\triangle = 2\rho$, $4z_1 = z + \frac{rz}{r+z}$ $= \frac{z^2 + 2rz}{r + z}$, and $z_1^1 = -(r - 2z_1) \pm \sqrt{r^2 + 4z_1^2}$.

We must reject the negative value, and for the other we have

$$z'_1 = 2z_1 + \frac{2z_1^2}{r} \text{ very nearly, } = 6.8649 \text{ miles.}$$

In a similar manner we find $z'_2 = 13.7425$, or $z'_2 = 2z'_1 + 0.0127$ miles. We should also find $z'_3 = 3z'_1$, very nearly, for $\triangle = 3\rho$; and so on.

We thus see that if the Earth were 490° Fah. warmer than it now is $\left(\text{since it is found that } \lambda = \frac{1}{490}\right)$; or in other words, if its own heat was such as to heat the air in contact with it to 490° more than 32° (supposing it to be 32° now), and to vary according to the law which we have supposed, the density of the atmosphere would be one-half what it is at the surface at the hight of about 7 miles, instead of $3\frac{1}{2}$ as at present; and one-fourth the density would be reached at about 14 miles, and so on. The hight of the atmosphere under such conditions would be more than double what it now is. If we suppose the density at the surface of the Earth to be about a million times as great as at the surface of the atmosphere, or $\triangle = 2^{20}\rho$, we shall find $z = 139$, nearly, under the conditions of high temperature; while in the other case it will be but 69 miles.

For the temperature which we have supposed the Earth to have, it would scarcely give out any light. To suppose the body self-luminous, it will be necessary to make t_0 about twice what we have supposed. We shall now make an application of our formulæ to the planet Jupiter, and since that

planet seems to be brighter, or to give out more light than what it reflects from the Sun, we shall suppose λt_0 equal to 2. The force of gravity on Jupiter is about 2.42 times terrestrial gravity; and if we make some allowance for an extensive Jovian atmosphere we may perhaps call $g = 2.5$.

If these values be put in Eq. (23), and we make $\triangle = 2\rho$, we shall have $3.6z_1 = \frac{z^2 + 3rz}{r + z}$, and $z = 1.2z_1$ nearly, $= 4.1156$ miles.

If we make $t_0 = 0$ we shall find $z = 1.3718$ miles, or about one-third of the other value. In a similar manner we shall find for the relation $\triangle = 4\rho$, $z = 8.2313$ miles, and so on.

If in Equation (19) we make $K = 1$, and $\lambda t_0 = 2$, we shall have $\triangle = 2\triangle_0$ ..(25) very nearly. Thus at the hight of about 4 miles the density of the Jovian atmosphere will, upon these suppositions, be the same as the density of the Earth's atmosphere at the surface of the Earth. If we suppose, as Mr. R. A. Proctor has done, that the density of Jupiter's atmosphere where the cloud-layers exist, is one-fourth of the density of the Earth's atmosphere at the Earth's surface, we shall have z for that case about 12 miles instead of 100 as he supposes. According to this investigation, then, Jupiter's atmosphere at his surface is either very dense, or its extent is not so great as Mr. Proctor imagines; or his temperature at the surface is greater than 1000° Fah.

We may perhaps reasonably assume $\triangle = 2^{50}\rho$ on Jupiter, and this value will give the hight of his atmosphere about 206 miles; and if we suppose $\triangle = 2^{20}\rho$ we shall find z equal to about 82 miles.

If we call $K = 1$, $t_0 = 980°$, $\lambda' = \frac{1}{980}$, $g = 2\frac{1}{2}$, we shall find, by Eq. (18), the hight of the barometer on Jupiter $82\frac{1}{2}$ inches. By Equation (19), we find upon the same suppositions that the pressure to the square inch, of Jupiter's atmosphere on his surface, is equal to $93\frac{3}{4}$ pounds.

If we take for Saturn $g = 1.1$, $\lambda t_0 = 2$, $\triangle = 2\rho$, we shall find $z = 9.3537$ miles; and for $\triangle = 2^{20}\rho$, $z = 187$ miles; and for $\triangle = 2^{50}\rho$, $z = 468$ miles. If we take $K = 1$, Eq. (19) gives $\triangle = \frac{3}{5}\triangle_0$, and the pressure to the square inch equals 18 pounds. The hight of the barometer by Eq. (18) equals 36 inches.

To make some application to the Sun, I shall assume $\lambda t_0 = 49$, which will give a temperature of the Sun's surface sufficiently high to correspond with our knowledge of the subject. We also have g equal to 27.2; and if $\triangle = 2\rho$ we find $z = 6.304$ miles. If we suppose $\triangle = 2^{1000}\rho$, we shall have $z = 6304$ miles as the corresponding hight of the solar atmosphere. We also find $\triangle = 15\ \triangle_0$ very nearly, if $K = 1$; and the pressure to the square inch is about 11000 pounds. The hight of the barometer would be 234.6 feet.

In these applications we have assumed $K = 1$ which supposes the mass of the atmosphere proportional to the mass of the planet which it surrounds. In the absence of all real knowledge on the subject we may as well make that assumption as any. The probability is that this supposition is an ap-

proximation to the truth. Equation (23) is independent of any supposition in relation to this matter.

5. In the following table I have arranged the various elements of the planetary atmospheres, which have been the subject of the foregoing investigation, on the supposition that $K = 1$, and $t_0 = 0$.

Planet.	Value of z for $\triangle = 2\rho$, in Miles.	Density at Surface.	Pressure at Surface on 1 sq. in. in lbs.	Hight of Barometer in inches.	Hight of the Atmosphere in Miles.
Mercury.....	7.40	0.214	3.21	13.9	719
Venus.....	3.92	0.765	11.47	26.3	392
Earth.....	3.43	1.000	15.00	30.0	343
Mars.....	11.31	0.092	1.38	9.1	1095
Jupiter.....	1.42	5.856	87.84	72.6	146
Saturn.....	3.13	1.210	18.11	33.0	313
Uranus.....	5.20	0.530	7.95	21.8	515
Neptune.....	4.36	0.615	9.22	23.5	436

The last column of this table, or that which gives the hight of the atmosphere, is based upon the supposition that the exterior limits of the planetary atmosphere have the same density for all, and that the Earth's atmosphere has a hight of 343 miles. It is not a little curious at first sight that Jupiter's atmosphere should be the least extensive in hight, while Mars's is the most extensive; but this is due to the great attractive influence of the one, and the smallness of the same element in the other. Though this table is based on an uncertain hypothesis, yet it seems to me that it is considerably instructive. Besides, the preceding theory will serve to test some of the hypotheses which are offered to account for the surface appearances of Jupiter.

The peculiar figure which Sir William Herschel found Saturn to present, which Bessel and others could not discover, and which Airy could not explain upon the theory of gravitation, is accounted for without difficulty by the currents in his atmosphere, as will be seen by consulting Wm. Ferrel's *Treatise on the Motion of Fluids relative to the Earth's Surface*, Art. 18, Fig. 1, Vol. I, *Math. Monthly;* and if Jupiter's atmosphere were sufficiently extensive he ought to present a similar figure.

Waterburgh, N. Y., October 19, 1876.

NOTE.

Since the above was written I have seen a report of Prof. S. P. Langley's experiments to determine the temperature of the solar surface. Physicists have heretofore differed considerably in their estimates of the Sun's temperature, Secchi putting it as high as 18 millions of degrees Fah., St. Claire Deville and others, between 3,000° and 20,000°. Prof. Langley's result favors the higher number. For convenience of calculation let us assume the solar temperature equal to 9,800,032° Fah., so that $\lambda t_0 = 20{,}000$.

Now let $K = 1$, then we find, by Equation (19), $\triangle = 0.0369\triangle_0$; or the

density of the solar atmosphere at the surface of the Sun, is but little more than one-half the density of hydrogen at the surface of the Earth, and at a temperature of 60° Fah. The pressure on a square inch of surface, is about 11,000 pounds Avoir. In the case of the Earth the density of the atmosphere at the surface of the Earth, is to the density at the surface of the atmosphere, at least as great 2^{100}: 1. If we assume the same ratio to hold for the Sun's atmosphere, Eq. (23) will give us for the hight of the solar atmosphere, 426,000 miles, or about the radius of the Sun. If we make $t_0 = 0$, we shall find the hight of the atmosphere, with the same ratio of densities, about 12½ miles; the density at the Sun's surface about 740 times that of the Earth's atmosphere at the surface of the Earth, or nearly equal to the mean density of the Sun. It will be noticed that in the case of high temperature, if we assume $K = 10$ (a very improbable value, it being too large), we still have $\triangle = 0.369_0 \triangle_0$, which gives a rare atmosphere. The following table will give the density at different hights above the Sun's surface:

Relative Density.	Hight in Miles.	Absolute Density, or $\triangle_0 = 1$.
$\triangle = 1$	0	0.03699
$\frac{1}{2}$	2536	0.01849
$\frac{1}{4}$	5104	0.00924
$\frac{1}{8}$	7702	0.00462
$\frac{1}{16}$	10330	0.00231
$\frac{1}{32}$	13000	0.00116
$\frac{1}{64}$	15683	0.00058
$\frac{1}{128}$	18403	0.00029
$\frac{1}{256}$	21362	0.00014

These numbers will help us to explain the rapid movements which Prof. C. A. Young and others have noticed in the solar atmosphere. If gases are pent up beneath the solar surface, but finally escape with great force, the rare atmosphere of the sun would not retard the motion like a dense one. The less rapid motion may be due to difference of specific gravity. The density of the hydrogen clouds can be calcnlated from the formulæ which have been given in the text. D. T.

November 24, 1876.

[*Minutes continued from page* 292.]

The minutes of the last meeting of the Board of Officers and Members in Council were read, and the recommendations of the Board were acted upon as follows:

A committee of five, to be appointed by the Chairman, after consultation, was, on motion of Mr. Price, ordered, who should accept Mr. Wooten's invitation, and examine his anthracite slack fires at Reading, or elsewhere along the line of the Reading Railroad.

The curators, on motion of Dr. Cresson, were requested to inquire of the Superintendent of the United States Mint whether it were practicable to arrange for the safe keeping and public exhibition of the cabinet of coins of the Society, in the Mint.

The librarian, was, on motion, authorized to proceed with the printing of the catalogue of the library, beginning with division VI; and directed to report to the Finance committee the plan and cost of the work. The Librarian explained that division VI, VII, and VIII, would make a volume nearly as large as that of division I to V, already published; and that division VI (Sociology, Commerce, Manufactures, War and Law) is ready to go to press, every title having been verified by reference to book or pamphlet. The other divisions (VII, Language, Belle Lettres, Fine Arts, Ethics, Metaphysics, Philanthropy and Religion; and VIII, Biography and Newspapers) will be ready for the press by the time division VI is printed. The press work must attend on a careful proof reading, and be therefore slow. The whole cannot be finished in less than eighteen months.

Pending nominations 809, 810, 811, 812 were read.

The name of Dr. James Gibbons Hunt was ordered to be taken from the roll of members, at his request.

Judge I. I. Hare's resignation on account of his inability to attend any meeting of the Society, was accepted.

Mr. Fraley reported the receipt of the quarterly interest of the Michaux Legacy, due Oct. 1st ult., $145.45, and its payment to the Treasurer.

Mr. Price offered the following resolution, which was discussed and passed:

Resolved, That this Society consents that, after providing for the Michaux grove of oaks, and for cultivation of other oaks in the park nursery, as provided by the resolutions of the Fairmount Park commissioners of March 12 (17?)th, 1870, and agreed to by the society on the 18th of March, 1870, the residue of the income of the Michaux legacy paid over to the Park commission may be applied to the pur-

purchase of other trees; and such other trees as well as oaks may be distributed not only to other parks, but to city squares, and in exchange with other public nurseries, and towards planting the grounds of institutions of learning and charity, to any extent that will not impair the primary purpose of said agreement of March, 1870.

And the meeting was adjourned.

Stated Meeting, Dec. 1st, 1876.

Present, 13 members.

Mr. ELI K. PRICE, in the Chair.

Letters of acknowledgment were received from the Societies at Göttingen July 15, (Proc. Vol. XIV) and Emden (94), and the Smithsonian Institution, July 22d (97).

A letter of envoy was received from the Society at Emden.

Donations for the Library were reported from the Academies and Societies at St. Petersburg, Berlin, Moscow, Emden, St. Gallen, Cherbourg, and Rotterdam; the Revue Politique, and London Nature; the Royal Astronomical, Geographical and Zoölogical Societies; the Museums at Cambridge, and Albany; New York State Library; Poughkeepsie Society of Natural Science; Professor E. D. Cope; and the Brazilian Centennial Commissioners.

On the report of the curator present of an interview with the superintendent of the mint, it was resolved that the report be adopted and the curators be requested to take such further measures as may be necessary for the placing of the Society's collection of coins under the care of the officers of the United States Mint.

Professor Hart read a paper entitled, "The Fairy Folk, or Fairy Lore of Spencer and Shakespeare," giving the romance or latin origin of the words fairy, &c., in contrast with the teutonic origin of the words elf, &c., assigning different characters to this species of imaginary creatures, supporting the distinction by numerous quotations, and the recital

of numerous typical legends. He defended his theory that Shakespeare's fairy lore was taken wholly from the life of the english people and was essentially and wholly teutonic, while Spencer's fairy characters represented the southern or romantic ideas of the world of enchantment.

The Annual Report of the Treasurer was read.

Pending nominations, Nos. 809 to 812, and new nominations, Nos. 813 to 822, were read.

On motion of Mr. Briggs, it was resolved that the words, "and report to the Society, on the originality of the process of Mr. Wooten, and whether it is deserving of the premium of $500 offered by the Society (Nov. 16th, 1866,) for the utilization of Anthracite Coal Slack," be added to the resolution passed at the last meeting to give it effect.

And the meeting was adjourned.

Stated Meeting, December 15th, 1876.

Present, 15 members.

Secretary, Professor KENDALL, in the Chair.

Mr. Frank Thompson, a newly elected member, was introduced to the presiding officer, and took his seat.

A photograph of Professor Alfred M. Mayer was received for the album, in a letter dated Stevens Institute, Hoboken, Dec. 11th, 1876.

The resignation of Mr. C. E. Smith was received by letter dated Dec. 9th, 1876, and on motion accepted.

The resignation of Dr. F. G. Smith was received through the Treasurer, and on motion accepted.

Letters acknowledging the reception of publications of the Society were received from Prof. Owen, dated British Museum, Nov. 24th (97); the London Statistical Society, Somerset House Terrace, Kings College Entrance, Strand, W. C., Nov. 28th (97); the Victoria Institute, Adelphi Terrace, Strand, W. C., Nov. 23 (97); and the Society of Antiquaries, Burlington House, Piccadilly, London, W. Nov. 22d, (97).

A letter of envoy was received from the Meteorological Office, London, Nov. 1876.

Donations for the Library were received from the Verein für Kunst at Ulm; Geographical Society and Revue Politique, Paris; Meteorological Committee and London Nature; Canadian Naturalist; Vermont Historical Society; Boston Natural History Society; E. L. De Forrest and Silliman's Journal; Editors of the Sanatarian, and American Chemist, New York; Penn Monthly; American Journal of Pharmacy and Medical News; and Bureau of Education at Washington.

A letter being read from the Deputy Secretary of the Commonwealth, dated Bellefonte, Pa. Dec. 2d, 1876, asking permission to copy the MSS. journal of Colonel Bard in 1756, at Fort Augusta, in the library of the Society, for publication in the new series of Archives of Pennsylvania, which was granted.

Mr. Walter made a communication to the Society upon the erroneous nature of certain statements respecting the foundations of the great tower of the Public Buildings at the corner of Broad and Market Streets.

Mr. Walter called the attention of the Society to some remarks which were made at the Stated Meeting held January 21, 1876, in which the foundations of the Tower of the New Public Buildings were referred to in a manner calculated to lead to erroneous impressions, and to shake the public confidence in that great work.

The remarks alluded to are found on page 181, Vol. xvi, No. 97, of the Proceedings, and are as follows: "Mr. Blodget recounted the experience of those who laid the foundation of the Masonic Temple, Broad and Filbert, where two gravels were found separated by three feet of quicksand, which required two powerful steam pumps 6″ and 8″ working night and day. The top of the quicksand layer was accidentally uncovered at the corner of the lot 40 feet deep, and this obliged the plan for laying the foundation to be entirely changed, at an expense of say $30,000.

"The great Tower of the Public Buildings, opposite to the Masonic Temple, has its foundation laid in the upper gravel, and there is a possibility of future disaster from the subjacent quicksand."

Mr. Walter stated that the foundations of the tower of the Masonic Temple were laid in what was formerly a ravine, as the dip of the strata underlying the Penn Square site clearly indicates, so that the vertical section of the excavations for the towers of the Temple will be found to be

very different from that of the excavations for the tower of the Public Buildings, and can in no wise be accepted as an indication of a want of stability in the underlying strata of the latter structure. He remarked that he obtained from Mr. Windrim, the Architect of the Temple, a memorandum of the thickness and character of the several strata through which the excavation passed, in reaching the foundation of the Tower, and which does not agree, in any particular, with the statement recorded in the proceedings of the Society.

According to Mr. Windrim, the first, or upper stratum was 10 feet in thickness, consisting of a sandy loam, resting on a clay bed of 5 feet deep, underlying which occurred a stratum of sandy loam 12 feet thick ; at about 2 feet from the bottom of this, or 25 feet below the street curb, the loam was permeated with water, supposed to have percolated through the ground when the adjacent squares were open. The next 10 feet consisted of stratified gravel, at the bottom of which it became hard, and at the depth of 1 foot more, being 38 feet below the street curb, the foundations were laid in a substratum of hard, compact gravel.

Mr. Walter remarked that he considers it proper thus to refer to the foundations of the tower of the Masonic Temple, as the statement in the Society's proceedings deduces from what is there erroneously said respecting the Masonic structure, that there existed a possibility of future disaster to the great tower of the Public Buildings. Such an inference is not only unfair and unjust, but it is damaging to public confidence in a great public work, and highly detrimental to the professional reputation of its architect.

The error of such an inference cannot fail to be apparent in view of the actual geological formation of the strata in which it is founded, and the manner of its founding. It is altogether a mistake to suppose that this great tower has its foundations "laid in the upper gravel." The facts are that in digging the foundation in question the first stratum passed through was the ordinary sandy loam, under which occurs a clay bed varying from 4 to 6 feet in thickness ; then follows a stratum of gravel, and below that one of sandy loam stratified with gravel and permeated with water from the surface drainage, producing what is sometimes called quicksand ; underlying this the hard gravel commences, and continues increasing in density as it increases in depth, until it assumes the character of "water gravel," from which rises the natural flow which supplies our wells. This stratum is some 10 feet in thickness, and in this the Tower of the Public Buildings is founded. After the excavation had been made, and prepared to receive the structure, a well was dug in the centre for the purpose of ascertaining the nature of the underlying soil, when it was found to consist of hard gravel, solid and compact throughout. This heavy stratum of gravel through which the natural spring water percolates, being considered by architects as the best possible foundation for a heavy structure, rock alone excepted.

Mr. Walter further stated that the foundation of this great Tower is 96

feet square, and 8 feet 6 inches deep, containing about 78,000 cubic feet, consisting of one entire mass of solid concrete, covering the whole space, and pressing equally upon its gravel bed, with which it in some measure necessarily amalgamates; and that in view of these facts, and of all the skill, care, and foresight that have been exercised in founding this, the greatest tower of the world, we need be under no apprehension of "the possibility of future disaster" to the structure.

Mr. E. K. Price, as Chairman of the Committee on the application of one-half of the income from the Michaux Legacy to botanical purposes, made a report on the Michaux and Cresson Trusts.

On motion it was: Resolved, that five hundred extra copies of the Report be printed for circulation and future use in the execution of the Trusts of the Cresson and Michaux Trusts.

Mr. Lesley read a paragraph from a recent private letter of M. Leo Lesquereux respecting new discoveries in the Carboniferous Flora of North America.

Mr. Lesley communicated a collection of Oil-well records made by Mr. J. F. Carll, Assistant on the Geological Survey of Pennsylvania, in charge of the survey in the Oil Regions of the State, with remarks on their value to men abroad and at home.

Professor Chase called attention to the Swedish statistics of color blindness.

Mr. Thompson described the investigations carried on at the shops at Altoona by the Pennsylvania Railroad Company, into the values of various signal lights and their possible combinations; and stated that in the experiences of that company not a single instance had been found among the employés of such color blindness as practically incapacitates an employé from using the series of four colors, white, green, red, and blue, to which signal lights are confined.

The report of the Finance Committee was read.

The annual appropriations for the ensuing year recommended in the report were, on motion, ordered.

Pending nominations, Nos. 809 to 822, and new nominations, 823 to 829, were read.

And the meeting was adjourned.

The Michaux Trees.

(Report of Committee read before the American Philosophical Society, December 15, 1876.)

To the American Philosophical Society and to the Fairmount Park Commissioners:

The Chairman of the Committee on the Michaux Fund of the said Society, and of the Committee on Trees and Nurseries of the latter, respectfully reports:

That he regards this year, 1876, as an era, from which will date a large advancement in the matters under the care of said Committees. Before it began very valuable importations of the rarest oaks had been made and planted in the Park Nursery, from which the first transplantations have lately been made into the Park grounds, and a few of them have been ordered into the *Campus* of the University of Pennsylvania this fall. Some planting out of the various trees in the Nursery had been made in the Park along the few avenues opened, and 1639 trees have been planted over the space occupied for the Centennial International Exhibition. The formation of the grounds within that space by the Board of Finance of the Exhibition and the planting therein are an invaluable acquisition to the Fairmount Park, as open waste fields have thereby been converted into beautiful gardens, with avenues, walks and fountains. It is true, that the garden of the Horticultural Hall was, to a large extent, planted with trees and flowers by Foreign and American exhibitors. James Veitch & Sons, of King's Road, Chelsea, S. W., near London, presented to the Park Commissioners their valuable collection of trees and plants, consisting chiefly of Rhododendrons.

The American exhibitors who had collected and planted in the garden of Horticultural Hall a rare variety of trees and ligneous plants were Thomas Meehan, of Germantown; Hoopes, Brother & Thomas, of West Chester, Pa.; S. B. Parsons & Sons, and R. B. Parson & Co., of Flushing, N. Y.; Miller & Hayes, of Mount Airy, Philadelphia; Mahlon Moon, of Morrisville, Pa.; and Robert Buist, of Philadelphia. They were actuated by a liberal desire that their collections should remain in the Park, and offered them at prices which they esteemed little over half the cost to them. It was an object to the Commissioners to secure these permanently for our Park, to be transplanted as thinning out shall be required for their healthy growth, and they have been secured by purchase.

The resources for this purchase should be here stated. They were as follows:

The city's appropriation, by the Park Commission applied for Nurseries in 1876	$1,500 00
Accumulated Interest on Elliott Cresson's Legacy	3,000 00
" " André F. Michaux's Legacy	414 60
Contributions by the following persons of $100 each, to wit: William L. Schaffer, George C. Thomas, Charles H. Rogers,	

Samuel Jeanes, Joseph Jeanes, Joshua T. Jeanes, Isaac F. Baker, Eli K. Price	$800 00
Moses Brown and J. C. Strawbridge, each $50	100 00
Together	$5,814 60

As the legacies of Elliott Cresson and André F. Michaux are enduring funds for planting in the Fairmount Park and elsewhere, it is proper here to show what are the trusts of those wills, and what are the obligations to the public incurred by the Park Commission in executing the agency committed to them.

ELLIOTT CRESSON'S LEGACY.

Elliott Cresson, by his last will and testament, made in 1857, provided as follows:

"I give and bequeath to the Mayor and community of Philadelphia the sum of $5,000, in trust, as a perpetual fund, the income of which I desire shall be annually, forever, expended in planting and renewing shade trees, especially in situations now exposing my fellow citizens to the heat of the sun."

An ordinance to provide for the investment of the principal and the application of the income of the Legacy of Elliott Cresson, Esq., to the City of Philadelphia, was passed June 10, 1859.

"A SUPPLEMENT

"*To 'An Ordinance to provide for the investment of the principal and the application of the income of the Legacy of Elliott Cresson, Esq., to the City of Philadelphia,' approved June* 20, 1859.

"Section 1. The Select and Common Councils of the City of Philadelphia do ordain, That the income of the fund bequeathed to the City of Philadelphia by Elliott Cresson, Esq., shall be expended in accordance with his will, by the Commissioners of the Park, constituted pursuant to the Act of Assembly, approved March 20, 1867."

The will of André Francois Michaux, of Vawreal, near Pointoise, France, dated the 4th September, 1855.

It revokes former wills. It declares as follows:

"Wishing to recognize the services and good reception and the cordial hospitality which my father and myself, together and separately, have received during our long and often perilous travels, in all the extent of the United States; as a mark of my lively gratitude, and also to contribute in that country to the extension and progress of agriculture, and more especially in sylviculture in the United States; I give and bequeath to the American Philosophical Society, at Philadelphia, of which I have the honor to be a member, the sum of twelve thousand dollars (at 5.50 the dollar, 64.800 francs). I give and bequeath to the Society of Agriculture and Art, &c., in the State of Massachusetts, Boston, in which I have the honor to be a member, the sum of eight thousand dollars (at 5.10 the dollar is, 43.200) these two sums together making one hundred and eight thousand francs, or again twenty thousand dollars. I give and bequeath the sole ownership

to these two above said Societies, and the usufruct to my aforesaid wife for her life."

The American Philosophical Society, believing that they could best execute their trust as to half the income of the Michaux Legacy in the Fairmount Park, made the following arrangement for that purpose:

"*Office of the Commissioners of Fairmount Park, No. 224 South Fifth Street, Philadelphia, March 12th*, 1870.

"At a meeting of the Commissioners of the Park, held this day, the following preamble and resolutions were adopted:

"*Whereas*, The American Philosophical Society has made a communication to this commission, proposing that the name of André Francois Michaux, who traveled long in this country, and described our oaks and forest trees in a work of great merit and splendor, should have his name, and that of his father (who had, by like travel and study rendered service to science,) honored in the Fairmount Park, in a manner, to be a memorial to their devotion to science, and to promote the objects which had occupied their lives, and has proposed, after the death of the widow of André Francois Michaux, to devote the interest or income of six thousand dollars bequeathed by him to said Society, to be expended in execution of the trust of his will in the said Park, for the purpose following; therefore,

"*Resolved*, That there shall be a grove of oaks in the Fairmount Park, forever, to bear the name of 'The Michaux Grove,' in which, if practicable, shall grow two oaks of every kind that will endure the climate.

"*Resolved*, That any surplus of revenue received by the commission from the Michaux Fund, after satisfying the requirements of the preceding resolution, shall be devoted to the cultivation of oaks of every variety capable of cultivation in our climate, in the Park nursery; which oaks, to the extent of two of each kind cultivated, be hereafter distributed to other Public Parks in the United States, under proper regulations to be hereafter prescribed."

Resolved, That this Society do agree to the terms contained in the preamble and resolutions of the Fairmount Park Commissioners, adopted on the 12th day of March, 1870, in the expectation and confidence that the planting of the Michaux Grove of Oaks may soon be commenced, so that the Grove shall early become one of the attractions of the Park." Proceedings Nov. 83, p. 312.

There appearing to be scope for a more extended benefit to be accomplished within the intention of Mr. Michaux, the powers of the Park Commission were extended by the American Philosophical Society.

At a meeting of the American Philosophical Society, November 17th, 1876, it was

Resolved, That this Society consents that, after providing for the Michaux Grove of Oaks, and for cultivation of other oaks in the Park Nursery, as provided by the resolutions of the Fairmount Park Commissioners, of March 12th, 1870, and agreed to by this Society on the 18th of March, 1870, the residue of the income of the Michaux Legacy paid

over to said Park Commission may be applied to the purchase of other trees; and such other trees as well as oaks may be distributed not only to other Public Parks but to City Squares, and in exchanges with other Public Nurseries, and in planting the grounds of Institutions of Learning and Charity, to any extent that will not impair the primary purposes of said agreement of March, 1870.

In respect to the intention of Elliot Cresson's will, to wit, "in planting and renewing shade trees, especially in situations now exposing my fellow citizens to the heat of the sun," the testator is to be taken to mean the greatest good to his fellow citizens by the shade of trees, and that would be where they most frequent, consistently with the requirements of business. It would not be to place trees in the thronged streets where such plantings would be obstructive and mask all business signs; but would properly be in all our public squares; in streets where people are yet so few as to permit the growth of trees without unduly obstructing passengers; certainly in the East Park, as Mr. Cresson knew it; and with a necessary expansion as business shall extend, to drive away such planting, and to follow the growth of the city, as the citizens move outward, and the Parks as they shall become more central and thronged. Charities are to be executed as near the intention as reasonably practicable; City and Girard heirs, 9 Wright's Reps. 9; and follow the growth and needs of their objects.

The Park Commission have from the Michaux legacy made importations that have given them the best collection of young and rare oaks in the country, containing about 1200 growing trees.

From the income of the Cresson legacy they have supplied two hundred dollars for trees in Independence Square, and have voted six hundred trees for the other Public Squares, from the Park Nursery; and two hundred and fifty trees for planting round the grounds of the University of Pennsylvania, and the University Hospital. The contiguous streets opened through the Almshouse ground, and elsewhere as new streets shall be opened, or built upon, might be supplied with trees from the Park Nursery.

There are now growing in the Park Nursery nearly eighty thousand trees and shrubs, of which about thirty thousand are of a size to plant out. Of the latter, there are, of *Arbor Vitæ*: American, 5,000; Siberia, 711; Tom Thumb, do., 1,047; Globe, do., 150; Hovey, do., 350; of White Pine, 350; Australian Pine, 200; Scotch Pine, 200; Balsam Fir, 600; Junipers, 370; Norway Spruce, 2,400; White do., 850; Hemlock, 500; Golden Willow, 32; Sweet Gum, 350; Tulip Poplar, 700; Cypress, 360; Forsythea, 400; Althea Var., 200; Mahonia, 30; Althea, 5,200; Norway Maple, 500; Privet, 150; European Larch, 30; European Birch, 240; English Elm, 400; Sugar Maple, 350; American Ash, 800; American Elm, 1,000; Kentucky Coffee Tree, 100; European Oaks, 800; American Chestnut, 25; Hornbeam, 3,128; American Beech, 50; European Beech, 2,000; Turkey Oaks, 350; Mist Tree, 200; American Larch, 200; Green Poplar, 96; Silver Maple, 440.

The City Councils and other officials will be authorized to draw on the above stock of trees, to the extent of the fulfilment of the trusts under the

wills of Cresson and Michaux, through the Park Commission, and even beyond those limits no doubt the Commission would consent for the public Squares, streets and Institutions.

Within the Park the Landscape Gardener will exert his skill to blend in beauty the self-sown forests there growing, with artistic planting, as the formation of new avenues and fresh grading will demand; where the new trees will be of kinds not native to our environs, and show in contrast the hand of Art; but at the same time greatly add to the variety and novelty of the trees and plants; so that the trees of the Park shall become a great *Arboretum*, and its flower beds become Botanic Gardens. Thus the landscape formed to please the taste, and the gardens to delight the eye, will become Schools of Science for all scholars and citizens. For this end, each section of the Park will be planted with the largest practicable variety of trees and plants.

That the variety of these may be greatly increased, we have purchased the trees exhibited in Horticultural Garden, and the gathering and planting of acorns and tree seeds have had in view mainly to increase the number of species, while providing the necessary stock whence to transplant trees over our Park of nearly three thousand acres in extent.

It is with pleasure I name those who have afforded the Committee cordial aid in supplying trees, acorns and tree seeds for the Fairmount Park during this Centennial year. They are, Dr. George B. Wood; Dr. George Smith, of Delaware County; Isaac Martin; Thomas S. Chambers; Mr. Smedley; Israel Lamborn, of Chester County; Dr. Kirkbride; Aubrey H. Smith; Philip C. Garrett; Isaac F. Baker; Clarance H. Clark; Dr. Morris Longstreth; Isaac Burke; George Stockham; Burnet Landreth; Thos. L. Craig, of Philadelphia; David Marshall, of San Francisco; Rollo Nichols, of Conn.; and Samuel Davenport, of South Australia, Commissioner to the Centennial Exhibition.

Through the latter the Committee received a collection of tree seeds from Tasmania; and have been informed of others on the way from South Australia. Mr. Davenport hopes to furnish the seeds of a Mountain Eucalyptus, with antimalarial potency, that will stand our climate.

The acorns and tree seeds furnished to the Park Nursery, have been, English White Oak, European Oak, Overcup White Oak, Post Oak, Chestnut White Oak, Weeping Oak, Willow Oak, Spanish Oak Acorns, Red Oak, Scarlet Oak, Pin Oak, White Oak, Turkey Oak, Bartram Oaks.

The American Ivy, Yellow Locust, do., pseudaccasia, Kentucky Coffee tree, Silver Ash, Black Ash, Horse Chestnuts; Larch, European and American; Nettle tree, Paw-paw, Magnolia, Flowering Crab Apple, Carolina and Green Buckthorn, Firethorn, Dogwood, Silver Bell, Winterberry, Blackhaw, Japan Callicarpa Cerulea, Skimmia Japonica; Celastris Scandens; Chinese Bignonia, Laburnums, Horse Chestnuts; White Birch, English Ash, Catalpa, Tulip Tree, Elm, Oriental Plane Trees.

Of Maples, Norway, Sycamore, Purple-leaved, Currant-leaved, Sugar and Rock Sugar.

Nor have we failed to think of the boys and girls of future times, and have planted and provided for the planting of the nuts of the Shellbark Hickory, large and small, English and black Walnuts, Chestnuts and Chincopins; the Nutmeg Pine.

Many of the above varieties of acorns and tree seeds have been supplied through Samuel Davenport to four Provinces of Australia, to wit: Victoria, Tasmania, Queensland, and New South Wales; and also to Dr. Schomburgk, of Adelaide, S. A.; to the Phillipine Islands, through Mr. Sebastian Vidal, Spanish Commissioner for the preservation of the forests of those islands; to Japan, through Rev. E. R. Beadle. The supply of acorns and tree seeds has been procured without any cost to any public or trust fund.

The Park Commission have received from Mr. Jacob Hoffner, of Cincinnati, Ohio, a Sago Palm, now in Horticultural Hall, formerly owned by Robert Morris and Henry Pratt, when they owned Lemon Hill, which plant is now supposed to be about 130 years old.

It is in this Centennial year that the artistic planting of the Park has fairly begun; and with the stock of trees on hand in the nursery, with moderate additions for the sake of variety, the formation of the landscapes may steadily proceed, without any serious expenditure, towards completion, as far as such work will admit of completion; for always old trees must decay, to be replaced by those that are both young and new. To fail to meet the annual expenditure for such purpose would be to fail to realize two great purposes of acquiring the Park, namely, the health and enjoyment of the people, and the increase of the resources of taxation commensurately with the interest of the capital invested in the Park. The Park must both be kept beautiful and attractive and the purity of the water supply preserved, or we become delinquent in performing a great duty towards our City, State and Country.

Fault has been found for delay in planting trees in the Park. This complaint is partly to be answered, if not fully, by the fact that it was necessary first to purchase the lands in the Park from many owners, including building lots in six village plots, necessarily a work of time, and after the purchases the ground had to be, and is yet to be, planned, graded, and avenues opened, before it could be known where to plant trees; and the Centennial International Exhibition necessarily caused delay in planning the West Park. There has been such delay during which it is to be regretted trees have not been growing; but that regret will be lessened when we reflect that the planning and planting can now go on rapidly, and be adapted to the buildings and gardens in the exhibition grounds with now an adequate supply of trees at command, and competent skill employed for planning and landscape gardening. These advantages will probably compensate for the loss by delay; and, indeed, more than compensate for them. Let us now proceed with such earnestness that the era of our Park's great improvements shall date from our National Centennial Year.

ELI K. PRICE, *Chairman, &c.*

Oil Well Records, selected from the collections of Mr. J. F. Carll, Assistant Geologist in charge of the Geological Survey of the Oil District of Pennsylvania. Communicated by J. P. Lesley, State Geologist.

(*American Philosophical Society, Dec.* 15, 1876.)

I hope to present at another meeting my views of the value of these records, and an analysis of the conclusions arrived at by Mr. Carll from a comprehensive study of many hundreds of such records collected by him during the last three years, since the commencement of the Second Geological Survey of the State in 1874; as well as from his practical experience of operations in the Oil Region since 1865.

The scientific value of well records is indeed limited by many conditions, each of which should be separately considered. But there can be no question of the utility of preserving them from destruction by publishing them in the printed archives of a society like this. Their publication will answer many questions put by men of science abroad and at home; will place at the service of investigators the original data of our own calculations; will invite the intelligence of thoughtful men in the Oil Region to a more careful scrutiny of such data; and above all, will induce many well borers to be more precise and complete in making up future records, and perhaps to communicate them for comparison. In this way only will it be possible to arrive at broad and true answers to moot questions which no one has yet succeeded in satisfactorily answering, except in a very local and unconnected manner.

Technical names and terms ought to be explained to those who have no business at the wells, but such a glossary would be a long one.

The height of each well mouth above the fixed ocean level datum of the Coast Survey should always be given; but it is often wanting, and then the value of the well record becomes comparatively low.

The well records of one locality have been grouped together; but it must be understood that not one in ten has been obtained, and the whole list is therefore but a meagre selection.

The first groups have been obtained from Companies operating in Warren and Venango Counties; others might have been added from Clarion and Butler Counties as specimens of the collections made in those Counties, to be published hereafter to show the geological persistency of the Oil-Sand Group from Tidioute to Butler.

Colorado Well, No. 1.

August 12th, 1870.

Located in Warren County, Southwest Township, Pa. on Pine Creek, or East Oil Creek, between Pleasantville and Tidioute, and two miles northeast of Enterprise.

Level of well mouth above ocean level in feet.*.....				1367
Casing to rock.....	36	to	36	= 1331

* On the provisional assumption that Oil City Depot is 995′ above *mean high tide P. R. R. datum;* and 7′ added for ocean level in Raritan Bay.

Interval of measures unnamed.....	236	to 270	=	1097
First Sand (1st S. S.).....	57	" 327	=	1040
Interval unnamed.....	88	" 415	=	952
Second Sand (2d S. S.).....	24	" 439	=	928
Interval unnamed.....	81	" 520	=	847
Third Sand (3d S. S.).....	46	" 566	=	801
Well carried down in "Pocket".....	9	" 575	=	792

Size of hole 5¼"; drilled wet; cased with 3¼" casing to shut off the water. Seed bag on casing below 2d S. S. say at about 445'.

A "mud vein" 8' below top of 3d S. S. at 528'.

The oil sand was of uniform color [white and pebbly] with the softest stratum on top, and appearances indicate that nearly if not quite all the oil comes in the well at 5 or 6 feet below the top of the 3d sand, between which points both torpedoes were exploded.

This well was pumped about thirty days, part of the time with a gas pump attached and part of the time without one.* The largest natural production without the gas pump was 4 barrels per day. The first day after the gas pump was applied the production increased to 6 barrels, from which point it gradually declined to less than 4 barrels.

On the 21st of November, 1870, it was torpedoed at a point 5½ feet below the top of the 3d S. S. It then produced 160 barrels per day for the first few days, but gradually declined to 13 barrels per day by the 1st of June, in the following year, 1871. The gas pump was again tried with no satisfactory results, and taken off as worthless or of no benefit to the well.

On December 21st, 1871, the production had declined to 10 barrels. A one quart nitro-glycerine torpedo was then exploded in the oil sand, which increased the production to 40 barrels per day. But this continued only a day or two. It immediately commenced decreasing, and on the 1st of August, 1872, about two years from the time it was first pumped, it had declined to its first natural production of 4 barrels per day.

During this month, August, 1872, the "volcanic treatment" was tried upon the well at three different times. The first time 4 burners were used, resulting in a slight increase of gas, but no increase of oil.†

The second time 7 burners were used, same results.

* Every oil well has more or less gas, which, separating from the oil at the bottom of the well rises between the tubing and casing and escapes through a pipe provided for the purpose, at the well mouth. A "gas pump" is an instrument which is attached to this escape pipe to relieve the rising gas from atmospheric pressure and thus facilitate and increase its flow. In many cases it not only augments the flow of gas but very materially improves the oil production of the well. A "Rotary" or "Gas Blower" is sometimes used for the same purpose.

† The "volcanic burner" is a patented article designed to increase the production of a well by intensely heating the fluid at the bottom. It consists of a case filled with chemical ingredients. After lowering it to the desired spot the materials are ignited by an electric spark. The operation is repeated until the desired heat has been obtained, when the tubing is at once put in and pumping resumed.

The third time 9 burners were used, same results, leaving the well at the end of the treatment with an appreciable increase of gas, but no improvement in the supply of oil.

A "scratcher" was also used in this well once, but with no benefit.*

By a series of experiments in casing and pumping, the salt water is supposed to come into the well with the oil near the top of the 3d S. S.

Colorado Well, No. 2.

Located on Colorado Oil Tract, 15 rods south of No. 1, and at the same altitude.

Dry cased hole. Salt water in second sand. Cased below second sand. Produced no oil and only about a quarter of a barrel of salt water per day.

Sand rocks about the same thickness as in well No. 1, but the third sand was of inferior quality, very little of it being white.

Colorado Well, No. 3.

August 20th, 1870.

Located 13 rods, N. 78° E., from No. 1.

Level of well mouth above ocean level in feet†					1404
Casing to rock	34	to	34	=	1370
?	279	"	313	=	1091
1st S. S.	44	"	357	=	1047
?	97	"	454	=	950
2d S. S.	21	"	475	=	929
?	84	"	559	=	845
3d S. S	45	"	604	=	800
? pocket.	8	"	612	=	792

Mud vein in 3d S. S. at 566 feet.

Cased at 475 feet.

3d S. S.
- top 6′ gray, with but little white.
- next 2′ white and soft (good).
- next 20′ white, but close.
- bottom 17′ mixed gray and white.

When first pumped it yielded only one barrel of oil per day and continued thus until a "scratcher" was used, which brought the production up to 15 barrels for a few days. It then declined to 4 barrels when a three pint nitro-glycerine torpedo was inserted 6 feet from the top of the third S. S. After this it produced 100 barrels per day for a short time.

* A "scratcher" is a round brush, about three feet long, made of steel wire. When it is to be used the tubing is drawn from the well, a few barrels of benzine are poured in and the scratcher is attached to the sucker rods and run down to the oil rock, where it is worked up and down for some time to scratch or scrub the walls of the well and assist the benzine in the dislodgment of whatever may have accumulated there.

† Oil City Depot provisionally 995 + P. R. R. datum.

The use of benzine in this well gave no satisfactory results, probably on account of salt water.

Three pint torpedo exploded 8 feet below top of 3d sand, May 30th, 1872. Daily production increased to 10 barrels, but declined to 5 barrels in 10 days. Torpedoed again, Dec. 18th, 1872. Result not stated.

Colorado Well, No. 4.

August 20th, 1872 (?).

Located 5½ rods S. E. of McKinney's N. E. corner.

Level of well mouth 26′ lower than No. 1*					1341
Drive pipe to rock	31	to	31	=	1310
?	205	"	236	=	1105
1st S. S.	45	"	281	=	1060
?	109	"	390	=	951
2d S. S.	21	"	411	=	930
?	84	"	495	=	846
3d S. S.	43	"	538	=	803
? pocket.	6	"	544	=	797

Drilled dry. Cased at 412 feet.

Best natural production, 2 barrels per day.

The hole was dry when the 3d sand was struck, and remained so until the drill had penetrated the 3d sand 5½ feet. At this point oil and salt water came in. The best part of the sand was from 505 feet to 515 feet; below this the sand was poor.

The first torpedo was exploded 5 feet below top of rock.
" second " " 10 " " "
" third " " 5 " " "
" fourth " " 15 " " " May 4th, 1872.

The production was increased by the first torpedo but soon settled back to about 5 barrels per day. The same effect followed the second and third. The fourth was a one quart nitro-glycerine blast, but it made very little increase in the oil flow. Benzining, flooding the sandrock with oil, and "scratching" the walls, all failed to produce beneficial results.†

* Oil City Depot provisionally 995′ + P. R. R. datum.

† A well is "flooded" by pouring sufficient fluid in at the top, while the pump remains idle, to fill up the shaft several hundred feet, more or less, above the oil sand. Benzine and crude oil are both used for this purpose; the object being to saturate the rock, under pressure, in order that the paraffin or other accumulations which may have adhered to its surface or obstructed its pores may be loosened and removed with the fluid when the pump is again started.

Colorado Well, No. 5.

Struck about August, 1871.

Located 14 rods south of No. 4.

Level of well mouth above ocean level, No. 1 + 31′ =*				1398
Drive pipe to rock	70	to	70	= 1328
1st and 2d Sands and intervening measures "regular" to top of 3d S. S.	423	"	493	= 905
3d S. S.	43	"	536	= 862
? pocket.	7	"	543	= 855

Wet hole. Cased at 217 feet. Crevice in 3d sand 11 feet below the top.

Natural production 60 barrels per day at commencement, but declined quite rapidly to 15 barrels. Remained thus for some time until torpedoed when it declined to 10 barrels.

First torpedo exploded 5 feet below top of 3d S. S.
Second " " 11 " " "
Third " " 5 " " "
Fourth " " 26 " " "

The production steadily declined; no beneficial results following the use of any of the torpedoes, except a slight temporary increase from the last.

The volcanic treatment was also tried without any marked effect.

The 3d sand was better than the average sands of other wells drilled in this neighborhood. The best and softest stratum commenced 3 feet below the top of the rock and continued to 7 feet. From 11 feet downward to the bottom of the rock the sand was good, but not as soft as in the upper division.

Colorado Well No. 6.

August 16th, 1871.

Level of well mouth above ocean*				
Casing to rock	32	feet.	32	=
?	318	to	350	=
1st S. S.	40	"	390	=
?	107	"	497	=
2d S. S.	19	"	516	=
?	81	"	597	=
3d S. S.	46	"	643	=
? pocket.	8	"	651	=

Wet hole, cased at 516.

Third sand very close and hard. Natural production less than 1 barrel per day.

First torpedo exploded 7 feet below top of 3d S. S. Production increased to 10 barrels but soon declined to 5 barrels.

Second torpedo 6 feet lower. Increase to 10 barrels but for shorter time than the first.

Scratched, with no benefit.

* Oil City Depot provisionally 935′ + P. R. R. datum + 7 for ocean level.

Third torpedo, May 8th, 1872, 7 feet lower than the second. Slight increase in oil.

Fourth torpedo, July 13th, 1872. 5 feet below top of 3d S. S., and 2 feet above the point at which the first was exploded. Increased production but did not pay for cost of torpedoing.

Abandoned August 2, 1872.

Colorado Well No. 7.

Struck August 8th, 1871.

Level of well mouth above ocean.....				
Drive pipe to rock.....	75 feet.		75	=
?.....	190	to	265	=
1st S. S.....	25	"	290	=
?.....	79	"	369	=
2d S. S.....	15	"	384	=
?.....	96	"	470	=
3d S. S.....	43	"	513	=
?.....pocket.	8	"	521	=

Wet hole. Cased at 386.

Mud vein 12 feet below top of 3d S. S. Natural production 7 barrels per day for a few days.

Third sand poor. From marks of oil on the tubing while the well was being pumped, it was inferred that the oil came in at a point in the sandrock just under the "mud vein," say from 12 to 15 feet below the top of the sand.

A three pint nitro-glycerine torpedo was discharged at the point in the sandrock where the oil appeared to come in. The production rose at once to 40 barrels per day, but declined rapidly to 20 barrels and then slowly to 17 barrels, at which figures it remained for more than three months, when it was flooded with water from well No. 10, then drilling within 15 rods of No. 7. When No. 10 was completed and tubed, and the water in it partially exhausted, this well, No. 7, began to recover its oil, but not in so large quantities as before it was flooded. From the time No. 10 began to pump oil, in January 1872, until July of the same year, No. 7 slowly declined in production and at the latter date was pumping only 2 barrels per day.

It was then torpedoed again at the same point as at first, after which it yielded, for a short time, 25 barrels per day and then declined rapidly to 4 barrels.

During the great "shut down movement of October, 1872," when all the walking-beams in the Oil Regions were stopt for 30 days, this well lay idle. But on starting up again in November, it produced 40 barrels per day for three days. Seven days later it was producing 8 barrels, and at the end of one month had settled to its old production before the "shut down," say 4 barrels.

Colorado Well No. 8.

Struck November, 1871.

Level of well mouth above ocean.....				
Casing to rock.....	10 feet.	10	=	
?.....	268 to	278	=	
1st S. S.....	30 "	308	=	
?.....	102 "	410	=	
2d S. S.....	20 "	430	=	
?.....	85 "	515	=	
3d S. S.....	46 "	561	=	
?.....pocket.	4 "	565	=	

Drilled dry. The casing was first put in at 180 feet. Failing to shut off the fresh water, it was drawn and the large hole continued down to 278 feet. At this point it was cased again, but both fresh water and salt water came in below as the drill went down, and the casing had to be drawn the second time. The well was then reamed down to the second sand, and 432 feet of casing put in, after which the hole remained perfectly dry until the oil sand was reached.

The upper 20 feet of the 3d S. S. was good. The lower (26 feet) was finer, of a grayish color and intermixed with white pebbles. When the 3d S. S. was struck, gas came in very freely and the hole quickly filled up many feet with oil and salt water.

Natural production 1½ barrels per day.

Torpedoed November 21, 1871 with 2 quarts of nitro-glycerine. Exploded 6 feet below top of 3d S. S. Result, 7 barrels per day. Declined rapidly.

Torpedoed December 15, 1871 with 3 pints of nitro-glycerine. Exploded at top of 3d. S. S. Result, not satisfactory.

Torpedoed May 2, 1872 with 1 quart nitro-glycerine. Exploded 15 feet below top of 3d S. S. Result, slight improvement.

Abandoned November 7, 1872.

Colorado Well, No. 9.

November, 1871.

Level of well mouth above ocean*.....				1508
Conductor to rock.....	18 feet.	18	=	1490
?.....	395 to	413	=	1095
1st S. S.....	28 "	441	=	1067
?.....	119 "	560	=	948
2d S. S.....	25 "	585	=	923
?.....	77 "	662	=	846
3d S. S.....	48 "	710	=	798
?.....pocket.	6 "	716	=	792

Drilled dry. Cased at 417½ feet.

Sand generally good.

Natural production about 3 barrels for a short time.

* Oil City Depot provisionally 995' + P. R. R. datum.

Nov. 29th, 1871. A two quart torpedo was used 11 feet below top of 3d S. S. Result, 10 barrels per day at first, with rapid decline.

Dec. 11th. A two quart torpedo was exploded at 6 feet in the sand. Result not as satisfactory as from the first one. On May 21, 1872, the production had decreased to less than 2 barrels per day. A 3 pint torpedo was then put in 17 feet below the top of the sand. Production for the next four months, 4 barrels per day. After the "30 days shut down" of Oct. 1872, it started to pump at less than 1 barrel per day, and with very little gas. This decline was attributed to the pumping of the wells on the adjoining tract after this one had been stopt.

Nov. 26th, 1872, it was treated with 6 volcanic burners, but with very slight improvement.

Dec. 7th, 1872, exploded a 3 pint torpedo 20 feet below the top of sand. Increase in oil very slight.

June 24th, 1873. Production, half barrel per day.

Colorado Well, No. 10.

January 10th, 1872.

Level of well mouth above ocean.....				
Drive pipe.....	42 feet.		42	=
?	198	to	240	=
1st S. S.....	40	"	280	=
?	89	"	369	=
2d S. S.....	14	"	383	=
?	87	"	470	=
3d S. S.....	43	"	513	=
? ....pocket.	9	"	522	=

Wet hole. Cased at 274 feet, 3¼ inch casing.

3d sand of ordinary quality.

Best part of it between 482 feet and 485 feet. This well when first pumped threw off a large quantity of fresh water, and then gradually changed to salt water. The first eight days of pumping the yield of oil did not exceed 3 barrels per day. On the tenth day it produced about 100 barrels of oil, and an equal quantity of salt water. It continued to do the same with but very little variation for four months, after which it slowly declined to 60 barrels of oil, and 60 barrels of salt water. It then declined rapidly to 28 barrels of oil and very little salt water. On the 27th of November, 1872, when the oil flow had declined to 23 barrels, the well was treated with 8 volcanic burners which increased the oil to 30 barrels per day, and also augmented the volume of water. After this, until about June 1st, 1873, the production of oil fluctuated from 22 barrels to 36 barrels per day. It then suddenly declined to 12 barrels per day, with a very perceptible increase of salt water.

Colorado Well, No. 11.

January 20th, 1872.

Level of well mouth above ocean*.....				
Wooden conductor to rock.....	17 feet.		17	=
?.....	380	to	397	=
1st S. S.....	30	"	427	=
?.....	117	"	544	=
2d S. S.....	25	"	569	=
?.....	76	"	645	=
3d S. S.....	46	"	691	=
?.....pocket.	8½	"	699½	=

Drilled dry. Cased at 392½ feet.

3d sand good in every part, particularly so between 662 feet and 670 feet.

Natural production 190 barrels daily for five days. Decreased rapidly to 130 barrels, and then more gradually until Sept. 11th, 1872, when it was pumping only 8 barrels. At this time a 3 pint torpedo was put in, 18 feet below the top of the 3d S. S., resulting in a daily production of 150 barrels for three days. It declined rapidly. On Sept. 21st, it had fallen to 24 barrels per day, and on Jan. 1st, 1873, to 4 barrels per day. A 3 pint torpedo was then used 12 feet in the sand, and the yield was thus brought up to 15 barrels per day for a short time.

Then commenced another rapid decline carrying the production down to 3 barrels per day by the 6th of May following, when another torpedo was inserted, resulting in a slight increase of oil.

On June 24th, 1873, while pumping 4 barrels per day, an attempt was made to fill up the well by putting oil and water in at the top. After 275 pails full had been poured in, it was ascertained that it had only filled up the bottom of the 5½ inch well hole 25 feet.

Colorado Well, No. 12.

March, 1872.

Level of well mouth above ocean*.....					1325
Drive pipe to rock.....	57	feet.	57	=	1268
?.....	198	to	255	=	1070
1st S. S.....	40	"	295	=	1030
?.....	90	"	385	=	940
2d S. S.....	12	"	397	=	928
?.....	87	"	484	=	841
3d S. S.....	48	"	532	=	793
?.....pocket.	13	"	545	=	780

Drilled dry. Cased at 220 feet.

* Oil City Depot provisionally 995′ + P. R. R. datum.

Best part of oil sand from 492 feet to 504 feet. Oil came in while running the second "bit" after the 3d sand was struck.*

Natural production 80 barrels per day, when first struck, declining slowly to 7 barrels by the 20th of August, 1872, when a 3 pint torpedo was put in 10 feet below the top of 3d sand. The result was an increase to 60 barrels the first 24 hours and a rapid decline to 10 barrels in 30 days. For two or three months after this it pumped steadily 10 barrels per day, and then began to decline. On May 24th, 1873, it was yielding only 3 barrels per day. Another torpedo was now exploded at a point 14½ feet below the top of the 3d S. S., bringing the production up to 30 barrels per day for two days, followed by a gradual decline to 10 barrels at the end of 30 days.

Colorado Well, No. 13.

July 20th, 1872.

Level of well mouth above ocean.....				
Wooden conductor to rock.....	15 feet.		15	=
?.....	374	to	389	=
1st S. S.....	29	"	418	=
?.....	73	"	491	=
2d S. S.....	19	"	510	=
?.....	98	"	608	=
3d S. S.....	38	"	646	=
Sand and slate alternating.....	8	"	654	=
Slate.....	4	"	658	=

Drilled dry. Cased at 205 feet.

Best sand from 3 to 8 feet below the top of 3d S. S. While drilling in this the well filled up rapidly.

Natural production 3 barrels per day. July 26th, exploded a 3 pint torpedo 5 feet below top of 3d S. S., causing but little improvement in production.

Aug. 2d, 1872, exploded another 3 pint torpedo one foot higher in the sand. Increase slight. Five days after torpedoing the well was producing 5 barrels.

Colorado Well, No. 14.

August 1st, 1872.

Level of well mouth above ocean.....				
Wooden conductor to rock.....	15 feet.		15	=
?.....	372	to	387	=
1st S. S.....	23	"	410	=
?.....	106	"	516	=

* A "bit" is the technical term applied to the chisel-shape tool used in drilling before the "reamer" or finishing tool is introduced. It is seldom "run" more than three feet without being withdrawn for sharpening. Oil struck "while running the second bit" means, therefore, that it was from three to five feet below the top of the sand rock.

2d S. S.		21	to 537	=
?		85	" 622	=
3d S. S.		45	" 667	=
?	pocket.	8	" 675	=

Drilled dry. Cased at 275 feet.

Salt water and gas appeared in 2d S. S. Third sand white and soft. Oil and salt water came in at a point 12 feet below its top. The best quality of sand was between 17 and 25 feet. Soft sand from 28 to 30 feet. Indications of a crevice between 38 and 40 feet.

Natural production 2 barrels per day.

Aug. 10th, 1872. Torpedoed (8 pints) at 18 feet below top of sand. Production rose to 14 barrels per day, but declined in 10 days to 8 barrels. Then sank to 6 barrels. Pumped steadily 6 barrels per day for a long time, then slowly began to decline, and on the 26th of June, 1873, it was pumping less than one barrel per day.

Colorado Well. No. 15.

August 25th, 1872.

Level of well mouth above ocean.....

Wooden conductor to rock		14 feet.	14	=
?		306	to 320	=
1st S. S.		27	" 347	=
?		83	" 430	=
2d S. S.		20	" 450	=
?		97	" 547	=
3d S. S.		38½	" 585½	=
?	pocket.	13½	" 599	=

Drilled dry. Cased at 173 feet.

Considerable gas in 2d S. S.

Softest part of 3d S. S. commenced at 3½ feet below its top, and continued down to 7 feet. At this point there was a large amount of gas and the well filled rapidly with fluid, the larger portion of it being salt water. From 14 to 18 feet below the top of the sand, the composition of the rock was such as to warrant the expectation of a good well, but there was so much fluid in the hole at this time that it could not be positively ascertained whether oil came in at this point or not.

Natural production 1½ barrels per day.

Aug. 29th, 1872. Torpedoed (3 pints) at 5 feet below top of 3d sand. Production first 24 hours thereafter, 12 barrels; and ten days later, 10 barrels per day.

Nov. 18th, 1872. Exploded a torpedo shell filled with giant powder, said to equal in strength a 3 pint nitro-glycerine torpedo. Before torpedoing the well was pumping 5 barrels per day. Four days afterwards, it was producing 6 barrels per day. The explosion filled up the well hole 10 feet. [Meaning, no doubt, with the crushed and broken fragments of the sand rock.]

This well declined very slowly, and on June 24th, 1873, was pumping 1⅔ barrels per day.

Colorado Well No. 16.

November 6th, 1872.

Level of well mouth above ocean.....				
Wooden conductor to rock.....	14 feet.		14	=
?.....	406	to	420	=
1st S. S.....	20	"	440	=
?.....	91	"	531	=
2d S. S.....	19	"	550	=
?.....	107	"	657	=
3d S. S.....	36	"	693	=
?.....pocket.	14	"	707	=

Drilled dry. Cased at 257½ feet.

Very small quantity of gas and salt water in 2d S. S.

Small quantity of salt water came in at the top of 3d S. S. Oil came in from 7 to 10 feet below the top. Sand good down to 14 feet. Good again from 20 to 23 feet. Below 23 feet it was fine and hard, but white, until near the bottom.

Natural production about 4 barrels of oil and 7 barrels of salt water per day.

Nov. 14th, torpedoed (3 pints) 9 feet below top of 3d S. S., it then produced 7 barrels of oil per day for about 10 days.

May 17th, 1873, pumping 1½ barrels per day. Torpedoed 20 feet below top of sand. Increased to 3 barrels per day for a short time.

June 24th, 1873, pumping 1½ barrels per day and continued to do so until Oct. 17th, 1873. Flooded with 7 barrels of Benzine, but slight increase either in gas or oil.

Nov. 16th, 1863, pumping 2 barrels per day.

Colorado Well No. 17.

November 23d, 1872.

Level of well mouth above ocean.....				
Wooden conductor to rock.....	13 feet.		13	=
?.....	396	to	409	=
4st S, S.....	21	"	430	=
?.....	101	"	531	=
2d S. S.....	19	"	550	=
?.....	89	"	639	=
3d S. S.....(not through S. S.)	40	"	679	=

Drilled dry. Cased at 237 feet.

Oil came in in small quantities while running the first "bit" in the 3d S. S. First show of salt water about 14 feet below top of sand. Sand soft and white down to 27 feet, then began to change to grey. From 31 feet to 40 feet it was very poor.

Natural production 1½ barrels per day. Torpedoed Dec. 3d, 1872 (3 pints), 14 feet below top of 3d S. S., and 48 hours afterward it was producing at the rate of 10 barrels per day.

The well declined very slowly, and on the 26th of June, 1873, it was still producing 4 barrels per day.

Colorado Well, No. 18.

January 25th, 1873.

Level of well mouth above ocean.....				
Wooden conductor to rock.....	15 feet.		15	=
Interval, containing 1st and 2d S. S.....	578	to	593	=
3d S. S.....	45	"	638	=
?.....pocket.	11	"	649	=

Drilled dry. Cased at 275 feet.

But little salt water and no oil came into the well until the drill had penetrated the 3d S. S. about 14 feet, here both oil and salt water came in, filling up the hole 75 feet or more. The best and softest part of the 3d S. S. was from 21 to 28 feet below the top of the rock.

Natural production less than one-half a barrel per day.

Torpedoed February 26, 1873 (3 pints), 14 feet below top of 3d S. S. Production brought up to 2 barrels of oil and 10 or 12 barrels of salt water per day. Pumped about four weeks at this rate, then commenced to increase in oil and decrease in salt water, and in ten days was pumping 24 barrels of oil per day. Pumped at this rate for ten or twelve days, then gradually declined, and four months after torpedoing, was pumping 9 barrels daily.

Colorado Well, No. 19.

February 19th, 1875.

Level of well mouth above ocean.....				
Wooden conductor to rock.....	15 feet.		15	=
Interval, containing 1st and 2d S. S.....	514	to	529	=
3d S. S.....	42	"	571	=
?.....	9½	"	580½	=

Drilled dry. Cased at 181 feet.

3d S. S. hard on top but at the depth of 5 feet changed for the better, and some oil and salt water came in. Rock remained quite close until the drill had gone down 13 feet in the sand when it became softer, but still there was no perceptible increase of fluid in the hole. From 13 feet down to 22 feet the sand was rather soft, and remained good down to 33 feet, from which downward it gradually grew finer and harder.

Natural production about 1½ barrels of oil and 12 to 15 barrels of salt water per day.

Feb. 22, 1876, torpedoed (3 pints) 14 feet below top of 3d S. S. After

torpedoing it commenced to pump at the rate of 15 barrels per day, and increased gradually, and on

March 1st, it was pumping 30 barrels per day.
" 20th, " " 34 " "
April 1st, " " 28 " "
" 8th, " " 30 " "
May 10th, " " 20 " "

Colorado Well, No. 20.

April 11th, 1876.

Level of well mouth above ocean.....			
Drive pipe to rock.....	41 feet.	41	=
Interval, containing 1st and 2d S. S.....	455 to	496	=
3d S. S.....	44 "	540	=
?.....pocket.	10 "	550	=

Drilled dry. Cased at 159 feet.

Softest part of 3d S. S. from 5 to 18 feet below the top. Oil began to come in with a very little salt water while drilling between 5 and 8 feet. Quite an increase of salt water at 24 feet. Gradual increase of gas all the way from 5 to 25 feet. Sand very hard at 39 feet, but good at the bottom of the rock.

Natural production 2½ barrels of oil, with about 8 barrels of salt water per day.

April 21st, 1876, torpedoed (3 pints) 8½ feet below top of 3d S. S. Production during the first twenty-four hours thereafter, 7 barrels of oil with not much increase of salt water and a small increase of gas.

May 10th, 1876, pumping 6 barrels of oil per day.

Colorado Well, No. 21.

June 7th, 1876.

Level of well mouth above ocean.....			
Wooden conductor to rock.....	10 feet.	10	=
Stove pipe casing*.....	14 "	14	=
Interval, containing 1st and 2d S. S.....	614 "	628	=
3d S. S.....	41 "	669	=
?.....pocket.	10 "	679	=

Drilled dry. Cased at 249 feet.

The softest and best part of the 3d S. S. commenced at 2 feet below its

* Sometimes the conductor is not properly driven to the rock. The drilling commences, and after going down some distance it is discovered that the loose material is falling in at its bottom. When the "cave" is not very serious a common, riveted, sheet iron "stove pipe" cylinder is shoved down to prevent its enlargement. This casing is merely a supplement or lining to the conductor, and represents what should have been the length of the conductor had it properly been put in originally.

top and continued down to 8 feet. Here oil and gas and salt water came into the hole. The sand was quite soft until the rock had been penetrated 30 feet, after this it was very hard until quite near the bottom, where it was found to be soft and coarse.

Natural production about 5 barrels of oil with 10 barrels of water during the first twenty-four hours. Three days later it was pumping 6 barrels of oil.

June 18th, 1876, pumping about 5½ barrels of oil.

June 20th, 1876, torpedoed (3 pints) 6 feet below top of sand. Result 15 barrels at first, gradually running down to 8½ by Nov. 25th.

Magnolia, No. 1.

Struck June, 1872.

Located on Ware Farm, Colorado District.

Level of well mouth above ocean*.....				
?.....	438	to	438	=
1st S. S.....	30	"	468	=
?.....	122	"	590	=
2d S. S.....	10	"	600	=
?.....	82	"	682	=
3d S. S.....	43	"	725	=
?.....pocket.	10	"	735	=

Drilled dry. Cased at 286 feet.

Show of oil at 688, and gas at 696.

3d S. S. rather dark and close.

Production, after one torpedo, about 2 barrels per day.

Pumped at intervals until January, 1873.

Magnolia, No. 2.

Struck July 7th, 1873.

Ware Farm, Colorado District.

Level of well mouth above ocean*.....					1615
7⅝ inch casing to rock.....	61	feet.	61	=	1554
?.....	691	to	752	=	868
3d S. S.....	42	"	794	=	821
Slate.....	1	"	795	=	820
Very hard shell.....	5	"	800	=	815
?.....pocket.	5	"	805	=	810

Drilled dry. Cased at 350 feet.

Best and softest part of 3d S. S. from near the top down to 12 feet. Good sand all the way down to 30 feet. Oil came in while drilling, but could not tell at what point, on account of the accumulation of salt water in the hole, coming down from the 2d S. S.

Natural production between 3 and 4 barrels per day.

* Oil City Depot, provisionally 995′ + P. R. R. datum.

July 9th, 1873. Torpedoed (3 pints) 7 feet below top of 3 S. S. Produced about 11 barrels the next 24 hours.

July 12th. Torpedoed (3 pints) 12 feet below top of rock. No increase.

Chick Well, No. 1.

January, 1872.

Colorado District.

Level of well mouth above ocean .....

?	598	to	598	=
2d S. S.....	19	"	617	=
?	85	"	702	=
3d S. S.....	34	"	736	=
? .....pocket.	25	"	761	=

"Measured by the drillers; probably incorrect."

Cased with $5\frac{3}{8}$" casing, but failed to shut off the water. Afterwards cased with $3\frac{1}{4}$" casing to depth of 450 feet.

3d S. S. about 43 feet thick. Close and dark. Best part of it from 717 to 720 feet. Fair at 734 feet.

Natural production less than one barrel per day.

Torpedoed at 705 feet and $717\frac{1}{2}$ feet. Increased to about 3 barrels per day. The well was pumped by heads, and in January, 1873, produced about 2 barrels per day.

Chick Well, No. 2.

Nov. 15th, 1873.

Colorado District.

Level of well mouth above ocean..... .....

?	0	to	734	=
3d S. S.....	45	"	779	=

Drilled dry. Cased at ———

Mud vein 5 feet below top of 3d S. S. Sand soft at top. Very good between 12 feet and 20 feet. Salt water at 24 feet.

The well filled up with oil about 200 feet before the salt water vein was struck.

Natural production about 10 barrels per day.

Dec. 3d, 1873, torpedoed 13 feet below top of 3d S. S. Production increased to 60 barrels per day. Declined gradually to 15 barrels by Feb. 15th, 1874.

Torpedoed a second time, resulting in a slight increase of oil for a short time.

Chick Well, No. 3.

February 13th, 1873.

Colorado District.

Level of well mouth above ocean.....

Wooden conductor to rock.....	20 feet.		20	
?	736	to	756	=
3d S. S.....	52	"	808	=
? .....pocket.	14	"	822	=

Drilled dry. Cased at 378 feet.

Strong flow of gas and oil when 3d S. S. was first struck, and the well filled up nearly 300 feet with oil.

Mud vein about 5 feet below top of 3d S. S. Sandrock rather ordinary for the first 25 feet, below that point quite hard, and at the bottom gray and dark. Softer than usual at 17 feet below the top. Salt water appeared between 25 and 30 feet below the top of sand.

Natural production, 75 barrels of oil and 100 barrels of salt water per day.

June 25th, 1873, the production was 25 barrels per day.

Potter Well, No. 1.

February 3d, 1873.

Colorado District.

Level of well mouth above ocean.....

Wooden conductor to rock.....	25 feet.	25	
?.....	645½ to	670½	=
3d S. S.....	47 "	717½	=
?.....pocket.	12½ "	730	=

Drilled dry. Cased at 266 feet.

3d S. S. good from top to bottom. Soft at 6 feet. Also from 12 to 15 feet, and extra quality at 42 feet. The lower part of the sand was softer than the upper, which is not generally the case in this locality.

The well filled up with fluid nearly 300 feet while drilling, but it was mostly composed of salt water.

Natural production, about 3 barrels of oil and 12 barrels of salt water per day.

Feb. 5th. Torpedoed 12 feet below top of 3d S. S. Bottom of hole filled up one foot with sand. Result, 12 barrels of oil and 50 barrels of salt water per day at first, declining to 6 barrels of oil in four days.

Feb. 10th. Torpedoed 6 feet below top of sand. Well filled up with sand 4 feet. Production slightly increased for a short time.

March 12th. Treated the well with 10 volcanic burners. But slight improvement.

April 2d. Torpedoed 21 feet below top of sand. No benefit.

April 21st, 1873. Abandoned the well.

Potter Well, No. 2.

February 11th, 1873.

Colorado District.

Well mouth above ocean.*.....				1550
Wooden conductor.....	15 feet.	15	=	1535
?.....	663 to	678	=	872
3d S. S.....	50 "	728	=	822
?.....pocket.	16 "	744	=	806

Drilled dry. Cased at 264 feet.

* Oil City Depot provisionally 995′ ÷ P. R. R. datum.

The 3d S. S. was good all the way through. Uncommonly so, for the first 20 feet, at which depth there was a good show of oil and gas. Below 25 feet the sand was somewhat harder and finer.

Natural production less than one barrel of oil and 8 or 9 barrels of salt water per day.

Feb. 13th. Torpedoed 20 feet below top of 3d S. S. The well filled up with sand 5 feet. Results, good. An increase both in oil and salt water. After several days' delay in getting the well to work, it pumped when first started up 16 barrels of oil and 100 barrels of salt water per day.

March 18th. Treated it with 10 volcanics. Results, an increase of gas and slight increase of oil.

June 20th, 1873, it was pumping 9 barrels of oil and 18 barrels of salt water.

Potter Well, No. 3.

March 21st, 1873.

Colorado District.

Well mouth above ocean*				1549
Wooden conductor to rock	16 feet.	16	=	1533
?	661 to	677	=	872
3d S. S.	50 "	727	=	822
? ....pocket.	8 "	735	=	814

Drilled dry. Cased at 270 feet.

The 3d S. S. was good throughout its entire thickness, soft for the first 24 feet, then somewhat harder, but not very hard in any part.

Natural production 2 barrels of oil and 6 or 8 barrels of salt water per day.

April 9th. Torpedoed (3 pint shell), production increased to 15 barrels of oil per day. Sustained the yield at this point for some time and then slowly declined to 8 barrels by the 20th of June following.

Potter Well No. 4.

March 21st, 1873.

Colorado District.

Level of well mouth above ocean.....

Wooden conductor to rock	19 feet.	19		
?	637 to	656	=	
3d S. S.	47 "	703	=	
? .....pocket.	10½ "	713½	=	

Drilled dry. Cased at 255 feet.

3d S. S. very uneven. Upper 13 feet soft, next 3 feet very hard, then 3 or 4 feet of soft sand. Below this finer and more even in composition.

Natural production 1 barrel of oil and 15 or 20 barrels of salt water per day.

March 26th. Torpedoed (3 pint shell) 16 feet below top of 3d S. S. Results, an increase to 4 or 5 barrels of oil and 100 barrels of salt water per

* Oil City Depot provisionally 935′ + P. R. R. datum.

day. Pumped in this way for some time and then gradually increased in oil until it produced 8 barrels per day. A decline then commenced both in oil and salt water. On June 24th, 1873, it had settled back to 5 barrels of oil per day, and on August 6th, to 3 barrels per day. At this time it was torpedoed again, and the next day was pumping at the rate of 8 barrels of oil per day.

On the 21st of August it had run down to 4 barrels per day, with a slight increase in the volume of gas. From this time it gradually declined to 1 barrel per day where it remained for two or three months.

Jan. 22, 1874. Flooded sandrock with benzine with no improvement either to oil or gas.

Jan 28th. Put in one of Quick & Fertig's Injectors.* After the first two injections the production rose to 2½ barrels, increasing to 5 barrels by the end of one week from the time the injector was put in. Benzine was used in the injector; and a gradual increase in production occurred until on July 24th, 1874, the well was pumping 17 barrels of oil per day.

Potter Well, No. 5.

April 4th, 1873.

Colorado District.

Level of well mouth above ocean.....

Wooden conductor to rock.....	16 feet.		16	=
?.....	655	to	671	=
3d S. S.....	46	"	717	=
?.....pocket.	11	"	728	=

Drilled dry. Cased at .

3d S. S. good. Upper 35 feet white and soft, then 5 feet of gray and the remaining 6 feet white but hard.

Natural production 2 barrels of oil and 8 to 10 barrels of salt water per day.

April 8th. Torpedoed and brought the production up to 140 barrels of oil per day, but it rapidly declined to 16 barrels, and on June 24th had still further declined to 12 barrels per day. It never pumped much salt water.

Potter Well, No. 6.

June 4th, 1873.

Colorado District.

Level of well mouth above ocean.....

Wooden conductor to rock.....	18 feet.		18	=

* The "injector" is a patented device by which perforations made in the tubing just above the pump chamber can be opened and closed at pleasure by the "sucker rods." Benzine is poured in at the top of the well and the pump kept in motion until the oil in the well and tubing is pumped out and benzine begins to show at the delivery pipe. The tubing is now full of benzine and the well is empty, or nearly so. On opening the apparatus in the injector, the 500 or 1000 feet of benzine in the tubing forces out strong jets in all directions against the walls of the well washing them down with force and giving more satisfactory results than can be obtained by a simple "flooding" with benzine. The process may be repeated again and again until the desired effect is produced.

?		639	to 657	=
3d S. S.		46	" 703	=
?	pocket.	12	" 715	=

Drilled dry. Cased at 240 feet.

3d S. S. good to the depth of 32 feet, below that, finer and not so white.

Oil came in near top of the sand and salt water 4 feet below the top.

Natural production 2 barrels of oil with 6 or 8 barrels of salt water per day.

June 6th. Torpedoed and increased the production to 150 barrels of oil daily. Declined in fourteen days to 36 barrels daily.

June 28th, 1875. Torpedoed 6 feet below top of 3d S. S. Result 3⅓ barrels per day.

Potter Well, No. 7.

July 11th, 1873.

Colorado District.

Level of well mouth above ocean.....

Wooden conductor to rock		16 feet.	16	=
?		629	to 645	=
3d S. S.		46	" 691	=
?	pocket.	13	" 704	=

Drilled dry. Cased at 229 feet.

3d S. S. very soft the first 12 feet, soft the next 14 feet and then harder and not so good as the drill approached the bottom. The well filled up with oil very fast after the sand was struck and while the first "bit" was being run in it.

Natural production 8 barrels per day.

July 14. Torpedoed (3 pint shell) 6½ feet below top of 3d S. S. Result, a production of 100 barrels of oil per day.

Nov. 20th, 1874. Production down to ⅔ of a barrel per day. Torpedoed (giant powder) 7½ feet below top of sand. No increase in gas and very little in oil.

From July, 1876, until the 11th of October following, this well produced 2 barrels per day, and then, without any treatment whatever, began to increase. On Oct. 25th it was producing 5½ barrels, Nov. 10th, 6⅔ barrels, and Nov. 25th, 5½ barrels.

Potter Well, No. 8.

April 27th, 1876.

Colorado District.

Level of well mouth above ocean.....

Wooden conductor to rock		15 feet.	15	=
?		616	to 631	=
3d S. S.		47	" 678	=
?	pocket.	10	" 688	=

Drilled dry. Cased at 225 feet.

3d S. S. first 4 feet very hard, next 8 feet very soft; then 9 feet a little firmer but not hard; then 10 feet softer; the remaining 16 feet being about an average sand. The first show of oil was at 21 feet below the top of the sand. Very little salt water and gas came into the hole while drilling, and when the well was tubed there was not more than 20 feet of fluid in it.

Natural production less than ¼ of a barrel of oil with about 5 barrels of salt water per day.

The first torpedo exploded 18 feet below top of sand increased the salt water slightly but not the oil and gas.

May 8th. Second torpedo (3 pint shell) 6 feet below top of sand. No improvement.

May 11th. Employed the scratcher. No improvement.

May 12th. Torpedoed 30 feet below top of sand. No increase either in oil or gas.

June 6th. Put in Quick & Fertig's injector. Still no improvement.

The well was abandoned June 22d, 1876, after having been pumped steadily for nearly two months.

Darling Well.

Drilled in 1865.

Gilson Run, Warren County.

Level of well mouth above ocean.....		
Drive pipe.....		57½ feet.
Soft slate.....	at	70 "
Very hard slate and 3 inch crevice.....	"	78 "
20 inch of salt water.....	"	145 "
Soft slate, 15 inch crevice.....	"	175 "
Very fine sandrock.....	"	185 "
12 inch crevice.....	"	230 "
Some oil, 15 inch crevice.....	"	290 "
Bottom of sandrock.....	"	310 "
Grey sandrock.....	"	355 "
Water course carrying away everything from the well.....	"	373 "
Some oil, 15 inch crevice.....	"	399 "
Fine white sand.....	"	411 "
Bottom of Sand.....	"	426 "
Flint and slate.....	"	450 "
Top of sandrock.....	"	514 "
Coarse white pebble sand, 6 inch crevice.....	"	522 "
Pebble rock and bottom of well.....	"	541 "

This well was never cased. The water was shut off by seed bag on tubing. It was pumped some time, producing several barrels of oil which is supposed to have come from the 2d S. S.

Clifton Well, No. 1

April, 1872.

Colorado District, southeast corner of tract 200.
Level of well mouth above ocean .....

?	0	to	402	=
1st S. S., (estimated).....	20	"	422	=
?	123	"	545	=
2d S. S.....	19	"	564	=
?	84	"	648	=
3d S. S.....	42	"	690	=

Drilled dry. Cased at 264 feet.
Very poor sand. Well never tubed.

Eclipse Wells.

Colorado District.
Level of well mouth above ocean.....

6¼ inch casing to rock.....	48	feet.	48	=
Mountain sand.....	162	to	210	=
?	240	"	450	=
1st S. S. (estimated).....	20	"	470	=
?	55	"	525	=
2d S. S. (estimated).....	10	"	535	=
?	45	"	580	=
3d S. S. (estimated).....	20	"	600	=
?	76	"	676	=
4th S. S.....	29	"	705	=
? .....pocket.	12	"	717	=

Cadwell Well.

Hill Farm, Colorado District.
Level of well mouth above ocean.....

6¼ inch casing to rock.....	36	to	36	=
?	280	"	266	=
1st S. S.....	29	"	295	=
?	105	"	400	=
2d S. S.....	18	"	418	=
?	83	"	501	=
3d S. S.....	46	"	547	=
? .....pocket.	4	"	551	=

Wet hole. Cased (3¼ inch) at 275 feet.
Abandoned Dec. 30th, 1875.

Onondaga Well.

East of Enterprise; Colorado District.
Level of well mouth above ocean.....

Drive pipe.....	62	feet.	62	=

?	137	to	199	=
S. S. gray	25(?)	"	224	=
?	236	"	455	=
2d S. S	15	"	470	=
?	51	"	521	=
3d S. S	13	"	534	=
?	36	"	570	=
4th S. S	15	"	585	=
?	90	"	675	=
5th S. S	26	"	701	=
Soft measures. No sandstone	99	"	800	=

Enterprise, Warren County.

Benedict Estate Wells, copied from office records.

Benedict Estate Well, No. 1.

Level of well mouth above ocean

?	192	to	192	=
1st S. S	50	"	242	=
?	58	"	300	=
2d S. S	4	"	304	=
?	31	"	335	=
3d S. S	10	"	345	=
?	117	"	462	=
4th S. S	15	"	477	=

Willard Well, No. 1.

Level of well mouth above ocean

Upper measures not noted	443	to	443	=
3d S. S	25	"	468	=

Harvey Well, No. 1.

Level of well mouth above ocean

?	180	feet.	180	=
1st S. S	49	to	229	=
?	71	"	300	=
2d S. S	6	"	306	=
?	16	"	322	=
3d S. S	12	"	334	=
?	95	"	429	=
4th S. S	6	"	435	=
?	14	"	449	=
5th S. S., oil	15	"	464	=

McKinney Well, No. 1.

Level of well mouth above ocean

Upper measures not noted	441	to	441	=
3d S. S	21	"	462	=

Reed Well.

Adjoining Benedict Estate. Record from memory of driller.

Level of well mouth above ocean.....				
?	150 feet.		150	=
1st S. S.....	52	to	202	=
Slate, blue.....	118	"	320	=
2d S. S.....	14	"	334	=
S. S., hard, gray.....	12	"	346	=
Slate, black.....	99	"	445	=
Stray S. S., gray.....	12	"	457	=
Slate.....	12	"	469	=
3d S. S.....[doubtful whether 12 or 22]	22	"	491?	=

Tidioute and Warren Oil Co.

Dennis Run between Triumph and Tidioute.
Records furnished by Major Cushing, of Tidioute.

Lease No. 58. *Well No.* 1.

Well mouth above ocean*.....					(?) 1230
?	45	to	45	=	1185
1st S. S.....	30 (?)	"	75?	=	1155
?	62	"	137	=	1093
2d S. S.....	25 (?)	"	162?	=	1068
?	133	"	295	=	935
Stray S. S.....	47	"	342	=	888
?.....pocket.	8	"	350	=	880
Depth of well.....					

Well No. 2.

Level of well mouth above ocean.....				
?	124	to	124	=
1st S. S.....	29	"	153	=
?	63	"	216	=
2d S. S.....	28	"	244	=
?	26	"	270	=
Stray S. S.....	16	"	286	=
?	90	"	376	=
3d S. S.....	48	"	424	=

Well No. 3.

Level of well mouth above ocean.....				
?	180	to	180	=
1st S. S.....	30	"	210	=
?	60	"	270	=
2d S. S.....	35	"	305	=
?	35	"	340	=

* Oil City Depot provisionally 995′ + P. R. R. Datum.

Stray S. S.	25	to	365	=
?	66	"	425	=
3d S. S.	50	"	475	=

At 436 first show of oil; at 445 second show of oil.

Well No. 4.

Level of well mouth above ocean.....

?	320	to	320	=
1st S. S.	35	"	355	=
?	55	"	410	=
2d S. S.	35	"	445	=
?	27	"	472	=
Stray S. S.	13	"	485	=
?	82	"	567	=
3d S. S.	27	"	594	=

Well No. 5.

Level of well mouth above ocean.....

?	332	to	332	=
1st S. S.	47	"	379	=
?	44	"	423	=
2d S. S.	35	"	458	=
?	29	"	487	=
Stray S. S.	13	"	500	=
?	84	"	584	=
3d S. S.	48	"	632	=

Triumph Oil Co.

Triumph, Warren Co. From books in office of Company.

Well No. 23.

Level of well mouth above ocean.....

?		660	to	660	=
3d S. S. 79 feet.	Fine hard sand	30	"	690	=
	Medium "	13	"	703	=
	Good "	17	"	720	=
	Pebble, (crevice at 722½)	10	"	730	=
	Good sand	9	"	739	=

Well No. 101.

Level of well mouth above ocean.....

?	662	to	662	=
3d S. S.	88	"	750	=
? pocket.	6	"	756	=

Sand very good.

Well No. 146.

Level of well mouth above ocean.....

?		694	to 694	=
3d S. S.		96	" 790	=

Coarsest from 764 to 774.
Salt Water at 773.

Well No. 148.

Level of well mouth above ocean.....

?		712	to 712	=
3d S. S.		103	" 815	=

Coarsest sand at 795 feet.
Mud at 732, 765 and 785.

Well No. 149.

On highest point of hill.

Level of well mouth above ocean.....

?		729	to 729	=
3d S. S. 74 feet.	Pebble	2	" 731	=
	Coarse sand	1	" 732	=
	Medium "	2	" 734	=
	Pebble	20	" 754	=
	Coarse sand	10	" 764	=
	Pebble	20	" 784	=
	Coarse sand	12	" 796	=
	Pebble	4	" 800	=
Medium sand		3	" 803	=
?	pocket.	6	" 809	=

Well No. 152. *B.*

Level of well mouth above ocean.....

?		712	to 712	=
3d S. S.		90	" 802	=
?	pocket.	3	" 805	=

Upper 60 feet fine.
Lower 30 feet coarse.

Well No. 224.

Level of well mouth above ocean.....

?		675	to 675	=
3d S. S.		107	" 782	=
?	pocket.	3	" 785	=

Good sand at 759.
Pebble at 782.

Well No. 237.

Level of well mouth above ocean....

?		667	to	667	=
3d S. S. 106 feet.	Fine sand	56	"	723	=
	Very coarse pebble	20	"	743	=
	Fine sand	10	"	753	=
	Grayish pebble	20	"	773	=
? pocket.		3	"	776	=

Mud at 701 and 710.
Salt water at 747.

Rising Sun Well.

Dennis Run. From S. Minor.
Level of well mouth above ocean....

?		104	to	104	=
1st S. S.		30	"	134	=
?		61	"	195	=
2d S. S.		28	"	223	=
?		117	"	340	=
3d S. S.		28	"	368	=

There was a gray rock about 20 feet below the 2d S. S., and sometimes 25 feet thick. All the rocks were very hard.

Dennis Run.

Wells of J. & E. W. Parshall on tract of N. Y. and Allegheny Oil Co., Dennis Run, near Tidioute. Furnished by Mr. Parshall.

Well No. 4.

Level of well mouth above ocean....

?		320	to	320	=
1st S. S., estimated		30	"	350	=
?	(including 2 S. S.)	230	"	580	=
3d S. S.		36	"	616	=
?	pocket.	5	"	621	=

Well No. 5.

Level of well mouth above ocean....

?		330	to	330	=
1st S. S., estimated		30	"	360	=
?	including 2d S. S.	230	"	590	=
3d S. S.		40	"	630	=

Well No. 7.

Level of well mouth above ocean....

?		240	to	240	=
1st S. S., estimated		30	"	270	=
?	including 2d S. S.	222	"	492	=

3d S. S.		50	to 542	=
?	pocket.	5	" 547	=

Well No. 9.

Level of well mouth above ocean				
?	including 1st S. S.	301	to 301	=
2d S. S., estimated.		25	" 326	=
?		115	" 441	=
3d S. S.		66	" 507	=
?	pocket.	6	" 513	=

Well No. 10.

Level of well mouth above ocean				
?		224	to 224	=
1st S. S., estimated.		30	" 254	=
?	including 2d S. S.	208	" 462	=
3d S. S.		69	" 531	=
?	pocket.	23	" 554	=

Well No. 12.

Level of well mouth above ocean				
?		255	to 255	=
1st S. S,, estimated		30	" 285	=
?	including 2d S. S.	233	" 518	=
3d S. S.		82	" 600	=
?	pocket.	20	" 620	=

Dennis Run Tract. E. W. Parshall's Wells.

Well No. 1.

Level of well mouth above ocean				
?		110	to 110	=
Mountain S. S.		37	" 147	=
?		151	" 298	=
1st S. S.		43	" 341	=
?		89	" 430	=
2d S. S.		30	" 460	=
?		91	" 551	=
3d S. S.		36	" 587	=
?		15	" 602	=

Well No. 2.

Level of well mouth above ocean				
?		73	to 73	=
Mountain S. S., estimated.		35	" 108	=
?		153	" 261	=

1st S. S., estimated	40	to	301	=
?	88	"	389	=
2d S. S., estimated	30	"	419	=
?	95	"	514	=
3d S. S.	50	"	564	=

Well No. 3.

Level of well mouth above ocean				
?.....including Mountain S. S.	274	to	274	=
1st S. S.	32	"	306	=
?.....including 2d S. S.	221	"	527	=
3d S. S.	50	"	577	=

Richardson, Tidioute. East side of Allegheny River. From Messrs. Rallston & Harrington.

Well No. 1.

Situated half way down the hill.

Level of well mouth above ocean				
?	84	to	84	=
1st S. S.	24	"	108	=
?	29	"	137	=
2d S. S.	23	"	160	=
?	76	"	236	=
3d S. S.	9	"	245	=

Well No. 2.

Up the hill.

Level of well mouth above ocean				
?	310	to	310	=
1st S. S.	20	"	330	=
?	24	"	354	=
2d S. S.	24	"	378	=
?	71	"	449	=
3d S. S.	11	"	460	=

NOTES.

In drilling an oil well, the measures passed through are necessarily divided into three groups or divisions. Each one of these divisions requires a specific treatment at the hands of the driller.

The first division is composed of Drift or the loose surface accumulations from the surrounding rocks; the second embraces the immediately underlying series of stratified rocks to the depth at which they contain water; and the third, the remainder of the well, including the oil sands at the bottom. The walls of the third division are generally self-supporting, remaining just as the drill leaves them, and this division, when the well is completed, is the only one where the rocky walls are bare.

The first division, owing to the loose and crumbling material of which it is composed, requires some mechanical device to prevent it from slipping or caving into the hole as it is drilled. Here the "conductor" is used A "conductor" may be simply a long box, without ends, made by spiking together four planks 2″ thick by 10″ wide—a "wooden conductor;" or it may be "drive pipe," composed of a number of cast-iron cylinders joined together and driven through the deposit; or it may be what is now more generally used, wrought-iron "surface casing," put in in a somewhat similar manner.

The "wooden conductor" can only be economically used where the surface deposit is of inconsiderable depth, as a pit must be sunk to the rock before it can be put in place. After the rock has been laid bare by the pick and shovel, the "conductor" is securely set between it and the derrick floor, the drill is let down to the rock through the conductor and the work of boring commences.

Where it is suspected that the floor of the Drift lies too deep to be reached by digging, cast-iron "drive pipe" is used. This pipe is cast in sections about 9′ long. A space of 4″ at each end is carefully turned in a lathe to a certain gauge, and the end is cut smoothly at right angles to the axis of the pipe, so that the joints will stand perpendicularly one upon the other. A joint of pipe is placed on end in the centre of the derrick between two "guides" which have been temporarily erected for the purpose of driving it. A heavy "mall" working between these guides is raised and dropped upon the pipe, slowly forcing it into the ground, precisely as piles are driven for docks, bridges, &c. When the top of a joint has been driven to the level of the derrick floor, a band of wrought-iron, made to fit the turned ends of the pipes and heated red-hot, is quickly slipped upon the end of the driven pipe and another joint at once set up. The contraction of this band in cooling holds the two joints firmly together and the driving process then goes on. In this way joint after joint is added and driven until solid rock is reached. As many as 23 joints have been used in a well. Great care is required when so long a "string of pipe" is driven to keep it straight and perpendicular, a broken band, or a large boulder encountered may cause the pipe to so far deviate from the perpendicular as to necessitate the abandonment of the well. To avoid this the pipe should be frequently cleaned out by the drill while being driven.

The more common method now employed in driving the well shafts through these thick accumulations of loose materials, is to use heavy wrought-iron casing, made expressly for the purpose and armed with a hardened collar or "shoe," at the bottom. This casing is made in joints about 20′ in length, which screw together in wrought-iron "thimbles," the same as do ordinary gas pipes. The tube being thin and light as compared with cast-iron drive pipe, cannot be so forcibly driven, but is worked down carefully by drilling a hole the full size of its inside diameter, and always keeping this hole open some feet in advance of the bottom of the pipe. In

(*Continued on page* 378.)

Columbia Farm (Old Story Farm,) on Oil Creek, one mile below Petroleum

Name of Well.	Depth of Conductor.	Rock Interval.	First Sand.			Rock Interval.	Second Sand.		
			Top.		Bottom.		Top.		Bottom.
Babcock..	36	304	340	50	390	52	442	25	467
Stewart...	18	276	294	39	333	103	436	26	462
Reiter....	18	399	417	47	464	74	538	25	563
Jones.....	27	292	319	37	356	105	461	24	485
Blocher ..	30	207	237	28	265	105	370	23	393
No. 58..	27	313	340	33	373	72	445	36	481
" 59..	18	282	300	19	319	124	443	21	464
" 61..	21	458	479	21	500	101	601	23	624
" 62..	27	270	497	32	529	73	602	34	636
" 64..	27	498	525	30	555	82	637	33	670
" 66..	18	518	536	31	567	101	668	23	691
" 69..	24	528	552	27	579	85	664	31	695
" 70..	24	146	170	29	199	111	310	27	337
" 71..	27	502	529	44	573	107	680	20	700
" 72..	18	272	290	35	325	105	430	40	470
" 73..	18	262	280	35	315	102	417	18	435
" 74..	18	257	275	30	305	105	410	27	437
" 77..	36	483	519	42	561	97	658	22	680
" 78..	18	487	505	25	530	123	653	22	675
" 80..	27	525	552	35	587	107	694	24	718
" 81..	18	322	340	45	385	100	485	30	515
" 82..	18	312	330	40	370	115	485	25	510
" 85..	27	258	285	55	340	95	435	20	455
" 86..	36	304	340	50	390	85	475	25	500
" 87..	45	315	360	32	392	98	490	24	514
" 89..	18	262	280	30	310	135	445	24	469
" 90..	18	287	305	50	355	105	460	20	480
" 91..	18	269	287	57	344	115	459	22	481
" 94..	54	171	225	20	245	120	365	33	398
" 96..	18	382	400	40	440	85	525	39	564
" 97..	45	290	335	50	385	103	488	20	508
" 99..	27	508	535	45	580	105	685	20	705
" 100..	27	375	402	53	455	84	539	15	554
" 101..	26	354	380	50	430	101	531	24	555
" 103..	27	283	310	40	350	90	440	41	481
" 104..	27	438	465	50	515	92	607	24	631
" 105..	18	339	357	53	410	90	500	27	527
" 106..	27	482	509	50	559	100	659	25	684
" 107..	27	281	308	40	348	102	450	26	476
" 108..	18	527	545	31	576	103	679	72	751
" 109..	9	521	530	40	570	110	680	30	710

Centre, Venango Co. Pa. From the books of the Columbia Oil Company.

Rock Interval.	Stray Sand. Top.		Stray Sand. Bottom.	Rock Interval.	Third Sand. Top.		Third Sand. Bottom.	Pocket.	Feet Depth.
76	543	30	573	20	593	50	643	10	653
58	520	30	550	21	571	53	624	3	627
49	612	30	642	20	662	54	716	6	722
68	553	30	583	20	603	51	654	3	657
76	469	31	500	10	510	52	562	8	570
39	520	32	552	20	572	43	615	3	618
46	510	30	540	19	559	53	612	6	618
53	677	33	710	21	731	49	780	15	795
44	680	30	710	19	729	41	770	11	781
53	723	30	753	17	770	40	810	0	810
63	754	32	786	18	804	46	850	0	850
52	747	34	718	12	793	39	832	5	837
60	397	33	430	17	447	45	492	3	495
54	754	30	784	21	805	40	845	5	850
37	507	25	532	30	562	42	604	0	604
74	509	33	542	14	556	50	606	0	606
69	506	30	536	15	551	37	588	7	595
78	758	28	786	12	798	45	843	0	843
54	729	31	760	15	775	40	815	6	821
67	785	27	812	18	830	36	866	2	868
53	568	31	599	19	618	34	652	3	655
40	550	33	583	17	600	38	638	3	641
45	500	33	533	22	555	40	595	3	598
51	551	29	580	20	600	45	645	3	648
54	568	30	598	21	618	50	668	3	671
46	515	31	546	20	566	39	605	5	610
53	533	26	559	15	574	38	612	3	615
64	545	29	574	12	586	37	623	4	627
49	447	33	480	20	500	40	540	5	545
52	616	27	643	12	655	33	688	2	690
50	558	30	588	22	610	50	660	5	665
52	757	28	785	24	809	41	850	3	853
73	627	30	657	18	675	50	725	2	727
63	618	33	651	17	668	30	698	3	701
71	552	21	573	17	590	50	640	2	642
60	691	26	717	19	736	50	786	5	791
45	572	30	602	35	637	40	677	1	678
53	737	30	767	17	784	50	834	5	839
64	540	29	569	16	585	54	639	3	642
33	784	27	811	13	824	44	868	2	870
65	775	27	802	13	815	39	854	1	855

Name of Well.	Depth of Conductor.	Rock Interval.	First Sand.			Rock Interval.	Second Sand.		
			Top.		Bottom.		Top.		Bottom.
No. 110..	36	464	500	37	537	143	680	20	700
" 111..	18	350	368	47	415	92	507	55	562
" 112..	27	313	340	35	375	80	455	35	490
" 113..	18	417	435	50	485	97	582	18	600
" 114..	27	405	432	72	504	72	576	24	600
" 115..	27	308	335	37	372	100	472	25	497
" 116..	27	445	472	38	510	108	618	21	639
" 117..	9	206	215	40	255	94	349	20	369
" 118..	18	517	535	32	567	99	666	25	691
" 119..	18	304	322	18	340	125	465	20	485
" 120..	18	492	510	30	540	102	642	23	665
" 121..	30	143	173	29	202	111	313	27	340
" 122..	36	134	170	40	210	90	300	35	335
" 123..	14	346	360	45	405	110	515	25	540
" 124..	16	294	310	30	340	135	475	25	500
" 125..	30	304	334	38	372	97	469	23	492
" 126..	15	441	456	20	476	124	600	24	624
" 127..	18	410	428	20	448	102	550	24	574
" 128..	18	312	330	56	386	100	486	25	511
" 129..	27	235	262	35	297	102	399	28	427
" 130..	20	286	306	41	347	100	447	28	475
" 131..	18	507	525	40	565	100	665	24	689
" 132..	16	217	233	30	263	110	373	24	397
" 133..	26	169	195	45	240	105	345	20	365
" 134..	13	470	483	39	522	98	620	35	655
" 135..	28	469	497	30	527	102	629	29	658
" 136..	13	417	430	71	501	72	573	23	596
" 137..	11	349	360	40	400	100	500	26	526
" 138..	14	366	380	45	425	95	520	22	542
" 139..	36	306	342	39	381	99	480	28	508

(*Continued from page* 375.)

the old filled up valley of the Tunauquaut, at Tarport, McKean Co. Pa. from 200′ to 300′ of this casing is required in each well.

Wells are spoken of indiscriminately as "small holes" or "wet holes" on the one hand, and as "cased holes" or "dry holes" on the other. A "small hole" must necessarily be a "wet" one, for there is no room to case off the water while drilling; and a "cased hole" must necessarily be a "dry" one, if the casing accomplishes the purpose for which it is used.

If now a well is to be drilled "wet," that is if no effort is to be made to shut off the water which comes into it from the second division mentioned above, to keep it from following the drill down to the oil rocks, then

Rock Interval.	Stray Sand. Top.		Bottom.	Rock Interval.	Third Sand. Top.		Bottom.	Pocket.	Feet Depth.
50	750	30	780	20	800	35	835	2	837
18	580	33	613	19	632	52	684	5	689
53	543	29	572	10	582	43	625	3	628
55	655	32	687	18	705	35	740	3	743
62	662	30	692	18	710	48	758	2	760
60	557	29	586	19	605	52	657	7	664
91	730	31	761	*	750	41	791	2	793
64	433	33	466	18	484	52	536	5	541
62	753	33	786	17	803	45	848	5	853
53	538	30	568	12	580	55	635	5	640
66	731	27	758	20	778	47	825	5	830
61	401	33	434	22	456	45	501	2	503
58	393	31	424	18	442	43	485	2	487
61	601	29	630	20	650	45	695	5	700
85	585	26	611	14	625	38	663	0	663
72	564	22	586	20	606	47	653	2	655
44	668	29	697	18	715	53	768	3	771
53	627	31	658	20	678	54	732	2	734
47	558	27	585	18	603	37	640	5	645
73	500	26	526	12	538	45	583	5	588
77	552	24	576	14	590	40	630	2	632
63	752	28	780	20	800	41	841	3	844
61	458	32	490	17	507	35	542	30	572
64	429	33	462	17	479	38	517	20	537
45	700	35	735	25	760	50	810	5	815
62	720	32	752	15	767	40	807	8	815
64	660	28	688	17	705	45	750	10	760
80	606	26	632	*	630	55	685	5	690
81	623	30	653	*	650	52	702	5	707
43	551	29	580	34	614	44	658	5	663

this "conductor" of which we have been speaking, whether of wood, cast-iron or casing, needs only to be 6″ in diameter, inside measurement. But if the well is to be drilled "dry," an 8″ conductor must be used, as will be seen further on.

In the first case (for a wet well), after the conductor is in place, a plain 5½″ hole is drilled all the way to the oil rocks; the water, meantime, nearly filling the well, or perhaps overflowing at the top of the conductor.

In the latter case (for a dry hole), an 8″ hole is to be drilled from the bottom of the conductor to a point below the water veins. When this is

* These are evidently errors in Nos. 116, 137 and 138 as the bottom of the Stray S. S. as here given overlaps upon the 3d S. S.

done, a 5⅝″ casing (inside diameter) is inserted, with a device on the bottom so arranged that it will form a water tight joint between the casing and wall of the well. A 5½′ hole is then continued down to the oil rocks from the inside of this last "string of casing." If the casing has been inserted to the proper depth and no water is encountered below it, the sand-pump will soon exhaust the water in the process of drilling, and the well be perfectly dry. But if lower veins of water are struck, the casing must be drawn, the hole reamed out to a greater depth, and the casing continued down below them. After the water is exhausted, a few pails full are poured in as circumstances demand; to moisten the drillings and furnish fluid for the sand-pump.

Comparing now the two wells when completed and ready for the pump, we find them both to be of the same size, 5½″ in diameter. One has simply a conductor through the upper division, all the stratified rocks being bare, is full of water, and has probably shown but very little indication of oil. The other has a conductor through the upper division, casing inside of this to the bottom of the middle division, and is dry—or at least was dry until the striking of the oil sand, when it immediately filled up several hundred feet with oil, or perhaps flowed.

The "dry" well is ready at once for the introduction of the pump tube; the "wet" one must be cased before it is tubed. The casing used for this purpose ("small casing,") is of 3¼″ inside diameter. A "water packer" or "seed bag" is attached to its lower end, which effectually closes the annular space between the outside of the casing and wall of the well. This "small casing," of course, must extend down to the bottom of the second division, the same as the large casing does in the "dry" well, for it has precisely the same duty to perform, the shutting off of the water in the upper rocks from the well shaft.

The well is now tubed with the ordinary 2″ "tubing," having a "working barrel" or pump chamber at the bottom, which is placed at or near the point where the oil enters.

Inside of the "tubing" are inserted the "sucker rods" which are connected in the derrick to the "walking beam," and operate the pump valves below.

Upon starting the pump, the "water packer" prevents any of the fluid outside of the casing from entering the well, and the water inside of the casing and in the uncased portion of the well is soon pumped out and the well is said to be "exhausted." As the well exhausts, the oil, which has been held back in the rock by the pressure of the heavy column of water above it, gradually forces its way into the well and is raised by the pump to the surface, unless it has a sufficient force of gas to flow of its own accord afterwards.

Note to Correspondents.

JANUARY 1, 1877.

Proceedings No. 96 forms a volume by itself (Vol. XV) and has just issued from the press. It will be sent out together with this No. 98, which forms the second part of Vol. XVI.

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